
REPORT No. 315

AERODYNAMIC CHARACTERISTICS OF AIRFOILS—VI

CONTINUATION OF REPORTS Nos. 93, 124, 182, 244, and 286

By

**NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS**

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INTRODUCTION

This collection of data on airfoils has been made from the published reports of a number of the leading aerodynamic laboratories of this country and Europe.¹ The information which was originally expressed according to the different customs of the several laboratories is here presented in a uniform series of charts and tables suitable for the use of designing engineers and for purposes of general reference.

It is a well-known fact that the results obtained in different laboratories, because of their individual methods of testing, are not strictly comparable even if proper scale corrections for size of model and speed of test are supplied. It is, therefore, unwise to compare too closely the coefficients of two wing sections tested in different laboratories. Tests of different wing sections from the same source, however, may be relied on to give true relative values.

The absolute system of coefficients has been used, since it is thought by the National Advisory Committee for Aeronautics that this system is the one most suited for international use and yet it is one from which a desired transformation can be easily made. For this purpose a set of transformation constants is given.

Each airfoil section is given a reference number, and the test data are presented in the form of curves from which the coefficients can be read with sufficient accuracy for designing purposes. The dimensions of the profile of each section are given at various stations along the chord in per cent of the chord length, the latter also serving as the datum line. The shape of the section is also shown with reasonable accuracy in order to enable one to more clearly visualize the section under consideration, the outside of the heavy line representing the profile.

The authority for the results here presented is given as the name of the laboratory at which the experiments were conducted, as explained under abbreviations, with the size of model, wind velocity, and year of test.

TRANSFORMATION CONSTANTS

For the convenience of those who prefer to use a system of units other than the absolute system, there is given below a table of transformation constants based on the standard condition adopted by the National Advisory Committee for Aeronautics of—

Temperature	= 15° C	= 59° F.
Pressure	= 760 mm Hg	= 29.92 in. Hg.
Humidity	= 0	
Gravity	= 9.80665 m/s ²	= 32.1740 ft./sec. ²

thus giving values of specific weight of air

$$W = 1.2255 \text{ kg/m}^3 = 0.07651 \text{ lb./cu. ft.}$$

¹ A previous collection of airfoil sections numbered 1 to 759 and Charts 1 to 20 may be found in N. A. C. A. Reports Nos. 93, 124, 182, 244, and 286.

and of density

$\rho = 0.12497 \text{ kg-m-}^4\text{s}^2$ in the French engineering or kilogram, meter, second system.

Or

$\rho = 0.002378 \text{ lb.-ft.-}^4\text{sec.}^2$ in the English or pound, foot, second system.

In absolute units	$P = CV^2\rho/2$
In kg/m^2 (m/s)	$P = .0625 CV^2$
In kg/m^2 (km/h)	$P = .004822 CV^2$
In lb./sq. ft. (ft./sec.)	$P = .001189 CV^2$
In lb./sq. ft. (mi./hr.)	$P = .002558 CV^2$

(Note that these constants are half as large as those used in Reports Nos. 93 and 124 and that the absolute coefficients used in this report are twice as large as the old coefficients. See Report No. 240 regarding change in absolute coefficients.)

INDEX

Four separate types of indexes are given—chart indexes which make it possible for a designer to select the wing section most suitable for the particular design in which he is interested; a group index which is arranged by countries and laboratories at which tests were conducted, each section also being designated by a reference number; an index of abbreviations, used on the characteristic sheets, to indicate the laboratories at which the tests were made; and an alphabetical index.

CHART INDEX

In order that the designer may easily pick out a wing section which is suited to the type of airplane on which he is working, four index charts are given which classify the wings according to their aerodynamic and structural properties. In the charts of this report a lower-case letter is placed adjacent to the reference number giving VL values, so that a comparison can be made without referring to the individual drawings. In this value V represents the wind velocity in feet per second and l a linear dimension, the chord length in feet.

In chart No. 21 the minimum drag C_D , is plotted against the L/D at one-fourth the maximum lift C_L . This chart should be used in choosing a wing section for a high-speed airplane, the wing sections being more suited for this use the farther they are from the lower left-hand corner.

In chart No. 22 the mean spar depth is plotted against the maximum lift C_L , in order to show the possible strength and lightness of the wing structure. The higher the maximum lift coefficient is, the smaller will be the wing area and the lighter the structural weight, and in the same way the greater the depth of the spars the lighter will be their weight, so that the sections the greatest distance from the lower left-hand corner will give the lightest and strongest wings. The "mean spar depth" is obtained by assuming the spars to be located, respectively, at 15 and 60 per cent of the chord, and by dividing the sum of their thicknesses, in per cent of chord length at these points, by 2.

In chart No. 23 the maximum L/D is plotted against the maximum lift C_L , which is of use in choosing the wing section for a slow and efficient airplane. In the same way as before the sections farthest from the lower left-hand corner are the best for this purpose.

In chart No. 24 the L/D at two-thirds the maximum lift C_L , is plotted against the maximum lift C_L . This chart can be used for choosing a section that will give an efficient climb or a long range at cruising speed. The best sections for this purpose will be farthest from the lower left-hand corner of the chart.

CHART INDEX

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INDEX OF ABBREVIATIONS

Name of laboratory at which tests were made	Abbreviations used on figures
Langley Memorial Aeronautical Laboratory of the National Advisory Committee for Aeronautics, U. S. A.	L. M. A. L.
Washington Navy Yard, U. S. A.-----	W. N. Y.
Engineering Division, McCook Field, U. S. A.-----	McC. F.
Ergebnisse der Aerodynamischen Versuchsanstalt zu Göttingen, Germany-----	Göttingen.
Service Technique de l'Aéronautique, France-----	S. T. Aé.
Laboratoire Aerotechnique de Rhode St. Genese-Bruxelles, Belgium-----	Rhode St. Genese.
Istituto Sperimentale Aeronautico, Italy-----	I. S. A.

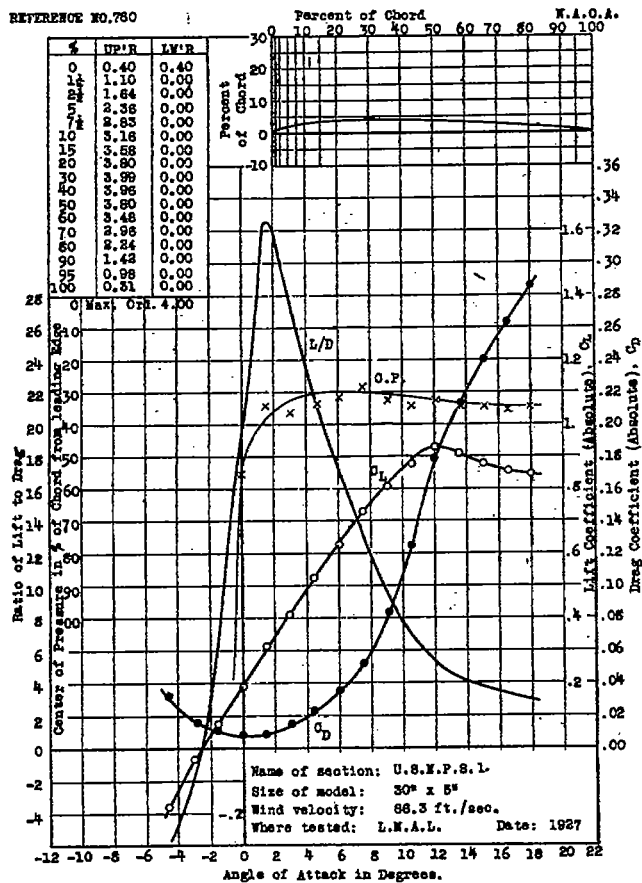
GROUP INDEX

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U. S. N. P. S. 1	L. M. A. L.	760	St. Cyr 162 (Royer)	S. T. A6. Lab.	810
U. S. N. P. S. 2	do	761	St. Cyr 170 (Royer)	do	811
U. S. N. P. S. 3	do	762	St. Cyr 174 (Royer)	do	812
U. S. N. P. S. 4	do	763	St. Cyr 233 (Bartel 37-Ib)	do	813
U. S. N. P. S. 5	do	764	St. Cyr 235 (Bartel 37-Ic)	do	814
U. S. N. P. S. 6	do	765	St. Cyr 237 (Bartel 15-Ic)	do	815
Martin M-I	W. N. Y.	766	St. Cyr 239 (Bartel 37-IIa)	do	816
Martin M-II	do	767	St. Cyr 240 (Bartel 37-IIb)	do	817
Martin M-III	do	768	St. Cyr 242 (Bartel 57-IIc)	do	818
R-3 (Root section)	McC. F.	769	St. Cyr 243 (Bartel 37-IIId)	do	819
U. S. A. 45M	do	770			
GERMANY			BELGIUM		
Göttingen 359	Göttingen	771	Rhode St. Genese 1	Rhode St. Genese	820
Göttingen 361	do	772	Rhode St. Genese 2	do	821
Göttingen 362	do	773	Rhode St. Genese 16	do	822
Göttingen 368	do	774	Rhode St. Genese 17	do	823
Göttingen 369	do	775	Rhode St. Genese 19	do	824
Göttingen 371	do	776	Rhode St. Genese 26	do	825
Göttingen 372	do	777	Rhode St. Genese 29	do	826
Göttingen 373	do	778	Rhode St. Genese 31	do	827
Göttingen 374	do	779	Rhode St. Genese 33	do	828
Göttingen 375	do	780	Rhode St. Genese 35	do	829
Göttingen 377	do	781	Rhode St. Genese 37	do	830
Göttingen 392	do	782			
Göttingen 397	do	783	ITALY		
Göttingen 399	do	784	I. S. A. 334	I. S. A.	831
Göttingen 401	do	785	I. S. A. 390	do	832
Göttingen 402	do	786	I. S. A. 472	do	833
Göttingen 403	do	787	I. S. A. 500	do	834
Göttingen 408	do	788	I. S. A. 501	do	835
Göttingen 417	do	789	I. S. A. 502	do	836
Göttingen 428	do	790	I. S. A. 507	do	837
Göttingen 437	do	791	I. S. A. 605	do	838
Göttingen 438	do	792	I. S. A. 663	do	839
Göttingen 439	do	793	I. S. A. 693	do	840
Göttingen 442	do	794	I. S. A. 695	do	841
Göttingen 443	do	795	I. S. A. 768	do	842
Göttingen 444	do	796	I. S. A. 776	do	843
Göttingen 445	do	797	I. S. A. 801	do	844
			I. S. A. 803	do	845
FRANCE			I. S. A. 804	do	846
Eiffel 359 (Nieuport Astra)	S. T. A6. Lab.	798	I. S. A. 805	do	847
Eiffel 386 (S. T. A6.)	do	799	I. S. A. 806	do	848
Eiffel 387 (S. T. A6.)	do	800	I. S. A. 807	do	849
Eiffel 402 (Pescara)	do	801	I. S. A. 809	do	850
Eiffel 429 (Lachassagne)	do	802	I. S. A. 812	do	851
Eiffel 432 (Lachassagne)	do	803	I. S. A. 820	do	852
Eiffel 433a (Chalambel)	do	804	I. S. A. 821	do	853
Eiffel 438 (Lachassagne)	do	805	I. S. A. 829	do	854
St. Cyr 152 (Royer)	do	806	I. S. A. 858	do	855
St. Cyr 153 (Royer)	do	807	I. S. A. 881a	do	856
St. Cyr 156 (Royer)	do	808	I. S. A. 881b	do	857
St. Cyr 157 (Royer)	do	809	I. S. A. 881c	do	858
			I. S. A. 911	do	859

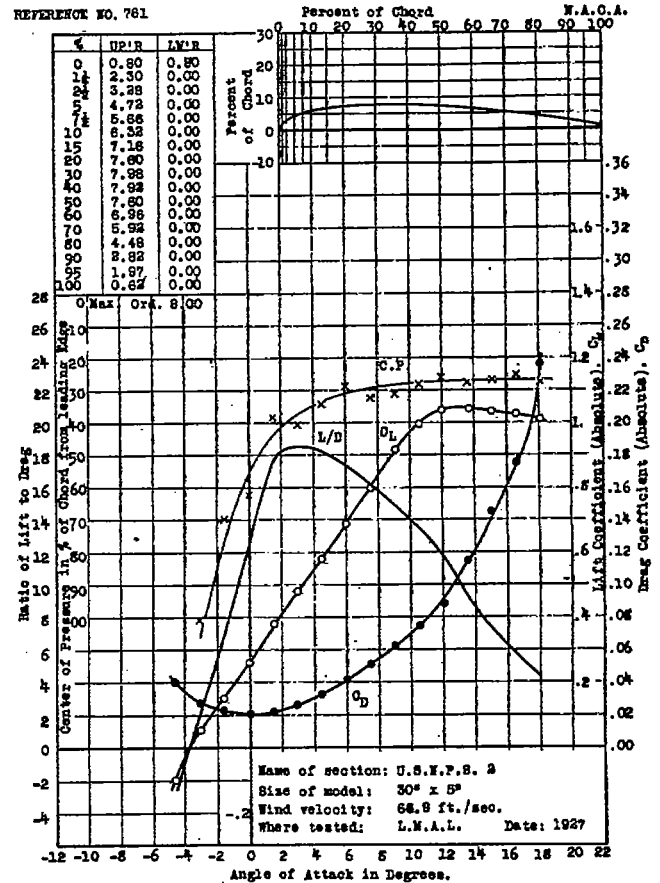
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Airfoil	Report reference number	Airfoil	Report reference number
Eiffel 359 (Nieuport Astra)	798	I. S. A. 804	846
Eiffel 386 (S. T. A6.)	799	I. S. A. 805	847
Eiffel 387 (S. T. A6.)	800	I. S. A. 806	848
Eiffel 402 (Pescara)	801	I. S. A. 807	849
Eiffel 429 (Lachassagne)	802	I. S. A. 809	850
Eiffel 432 (Lachassagne)	803	I. S. A. 812	851
Eiffel 433a (Chalambel)	804	I. S. A. 820	852
Eiffel 438 (Lachassagne)	805	I. S. A. 821	853
Göttingen 359	771	I. S. A. 829	854
Göttingen 361	772	I. S. A. 858	855
Göttingen 362	773	I. S. A. 881a	856
Göttingen 363	774	I. S. A. 881b	857
Göttingen 369	775	I. S. A. 881c	858
Göttingen 371	776	I. S. A. 911	859
Göttingen 372	777	Martin M-I	766
Göttingen 373	778	Martin M-II	767
Göttingen 374	779	Martin M-III	768
Göttingen 375	780	R-3 (Root Section)	769
Göttingen 377	781	Rhode St. Genese 1	820
Göttingen 392	782	Rhode St. Genese 2	821
Göttingen 397	783	Rhode St. Genese 16	822
Göttingen 399	784	Rhode St. Genese 17	823
Göttingen 401	785	Rhode St. Genese 19	824
Göttingen 402	786	Rhode St. Genese 26	825
Göttingen 403	787	Rhode St. Genese 29	826
Göttingen 408	788	Rhode St. Genese 31	827
Göttingen 417	789	Rhode St. Genese 33	828
Göttingen 428	790	Rhode St. Genese 35	829
Göttingen 437	791	Rhode St. Genese 37	830
Göttingen 438	792	St. Cyr 152 (Royer)	806
Göttingen 439	793	St. Cyr 153 (Royer)	807
Göttingen 442	794	St. Cyr 156 (Royer)	808
Göttingen 443	795	St. Cyr 157 (Royer)	809
Göttingen 444	796	St. Cyr 162 (Royer)	810
Göttingen 445	797	St. Cyr 170 (Royer)	811
I. S. A. 334	831	St. Cyr 174 (Royer)	812
I. S. A. 390	832	St. Cyr 233 (Bartel 37-Ib)	813
I. S. A. 472	833	St. Cyr 235 (Bartel 37-Ic)	814
I. S. A. 500	834	St. Cyr 237 (Bartel 15-Ic)	815
I. S. A. 501	835	St. Cyr 239 (Bartel 37-IIa)	816
I. S. A. 502	836	St. Cyr 240 (Bartel 37-IIb)	817
I. S. A. 507	837	St. Cyr 242 (Bartel 57-IIc)	818
I. S. A. 605	838	St. Cyr 243 (Bartel 37-IIIC)	819
I. S. A. 663	839	U. S. A. 45M	770
I. S. A. 693	840	U. S. N. P. S. 1	760
I. S. A. 695	841	U. S. N. P. S. 2	761
I. S. A. 768	842	U. S. N. P. S. 3	762
I. S. A. 776	843	U. S. N. P. S. 4	763
I. S. A. 801	844	U. S. N. P. S. 5	764
I. S. A. 803	845	U. S. N. P. S. 6	765

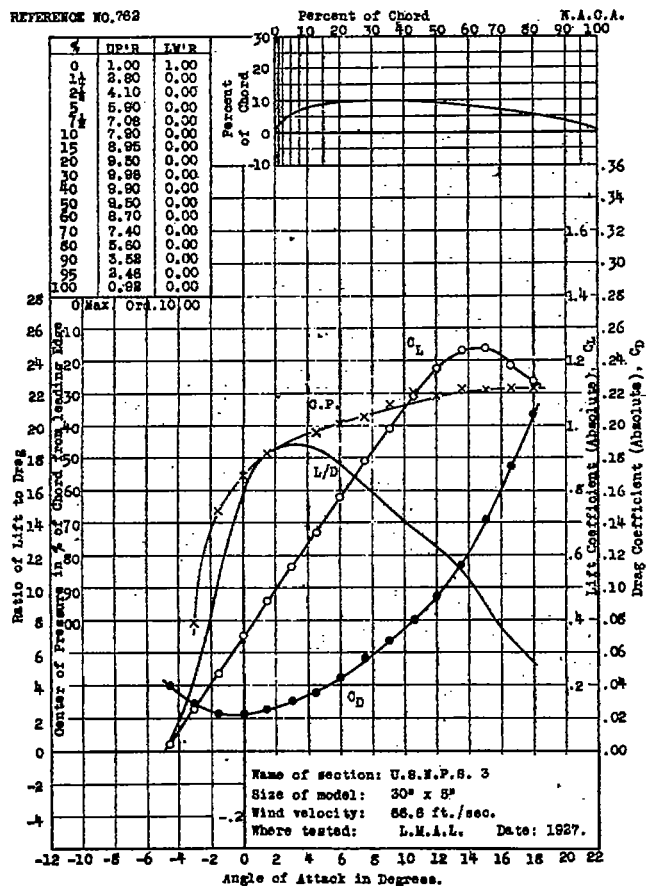
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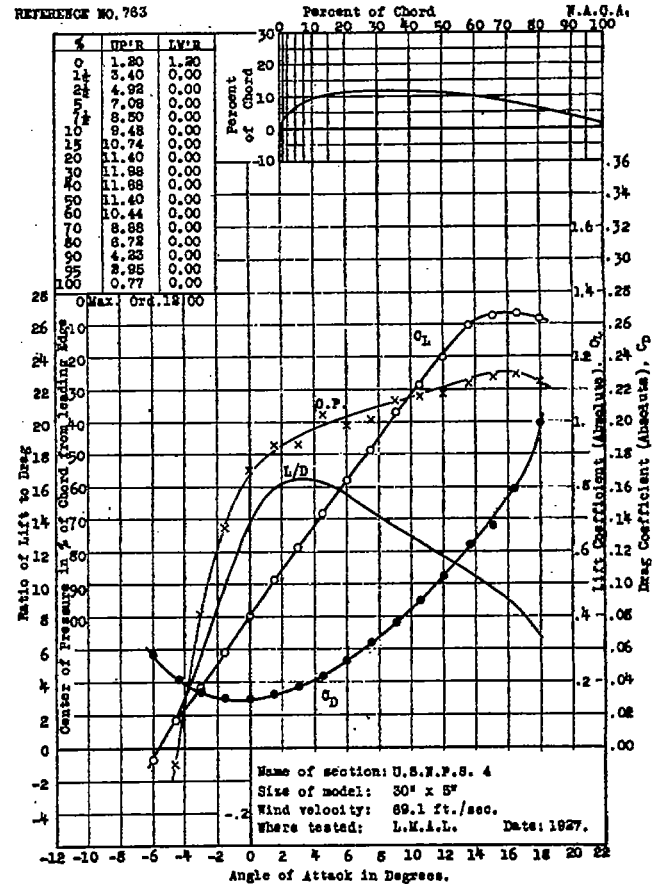
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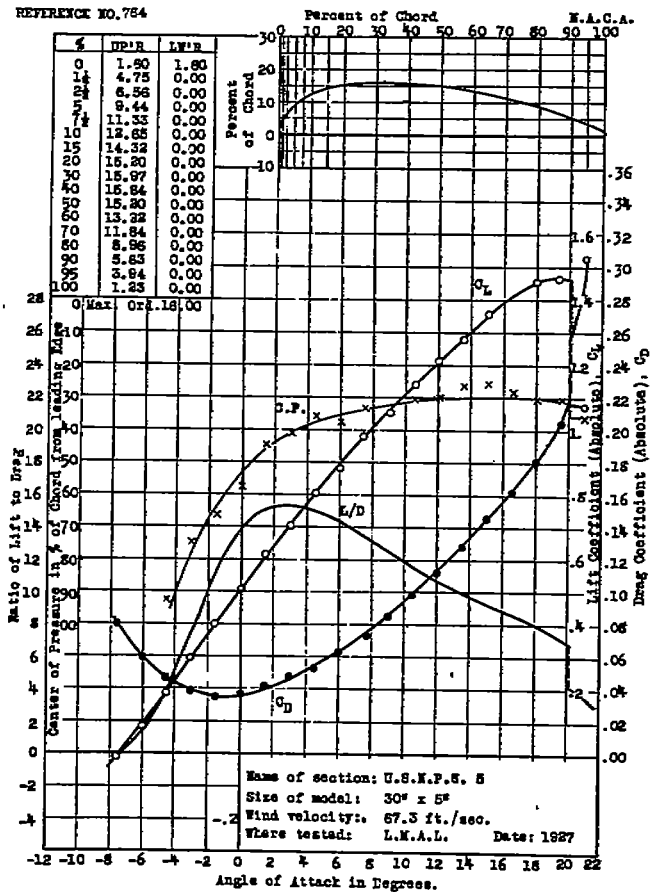
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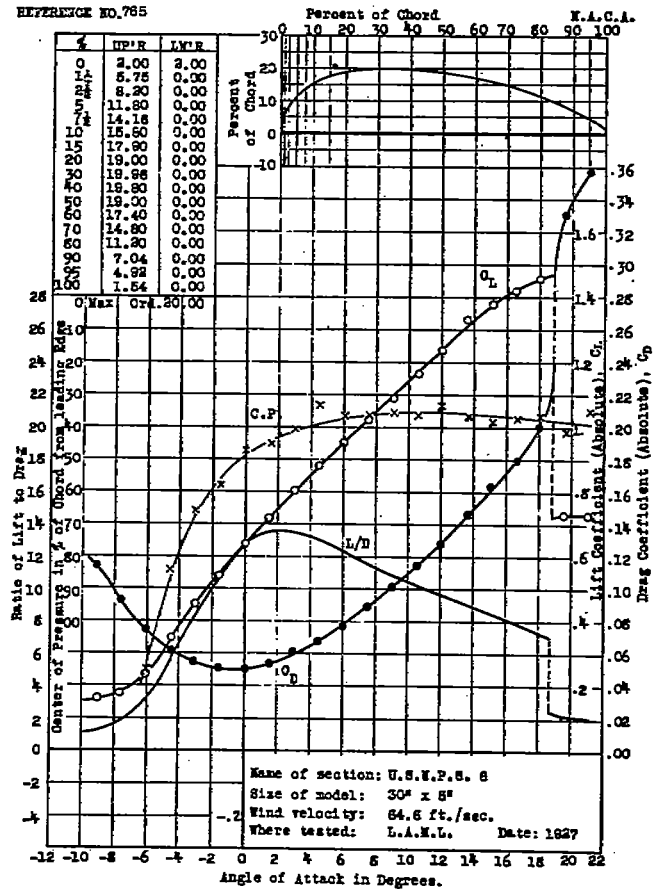
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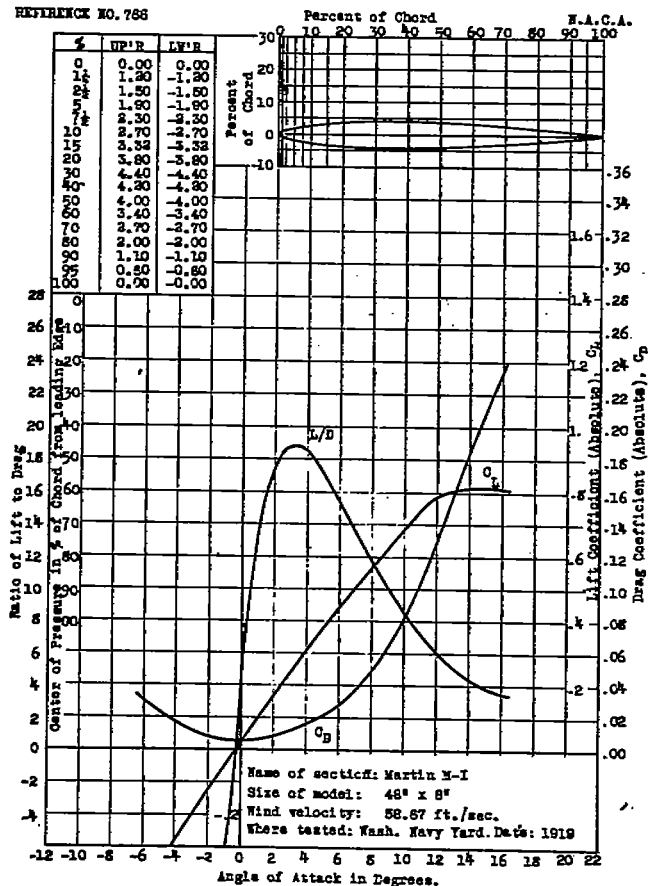
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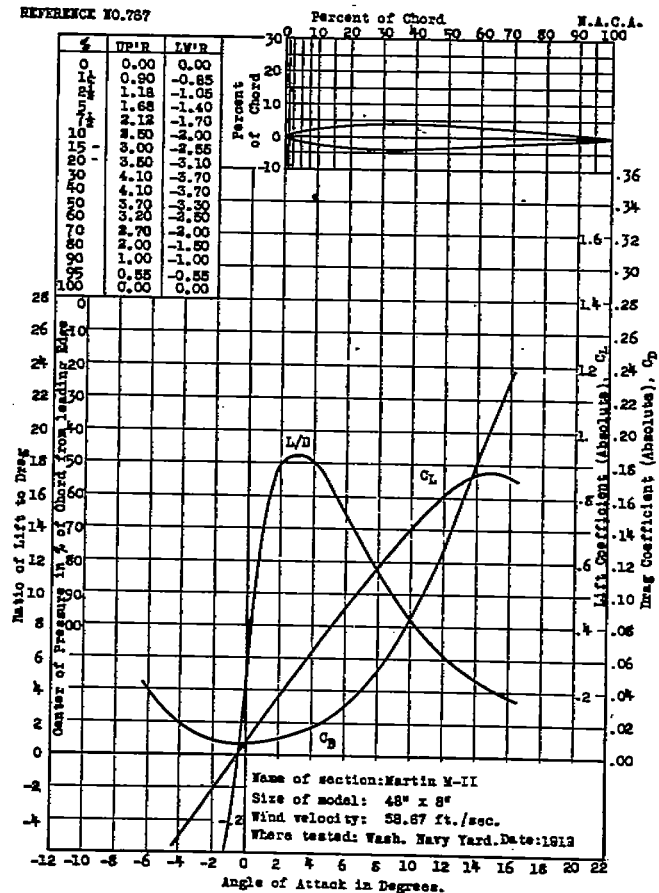
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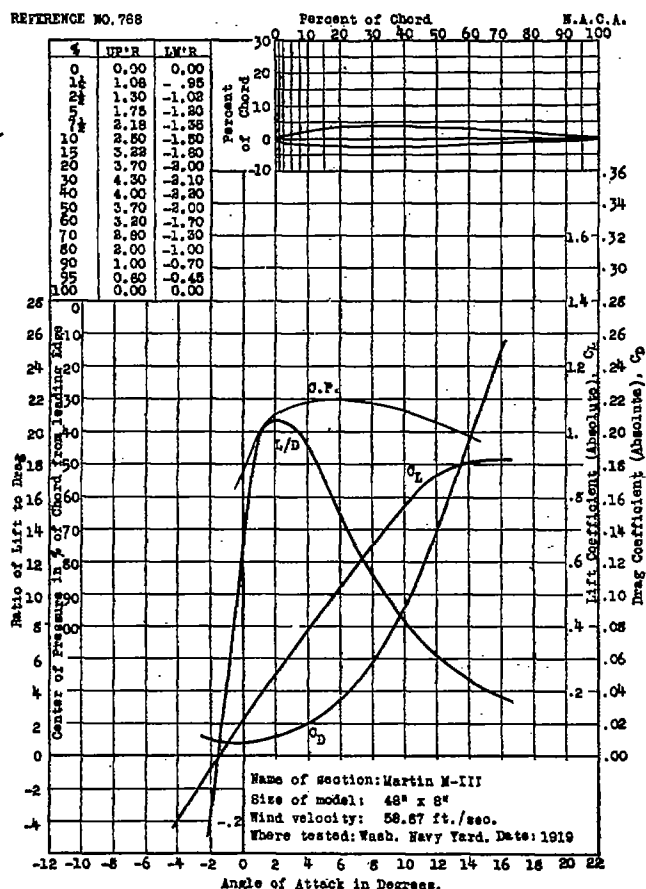
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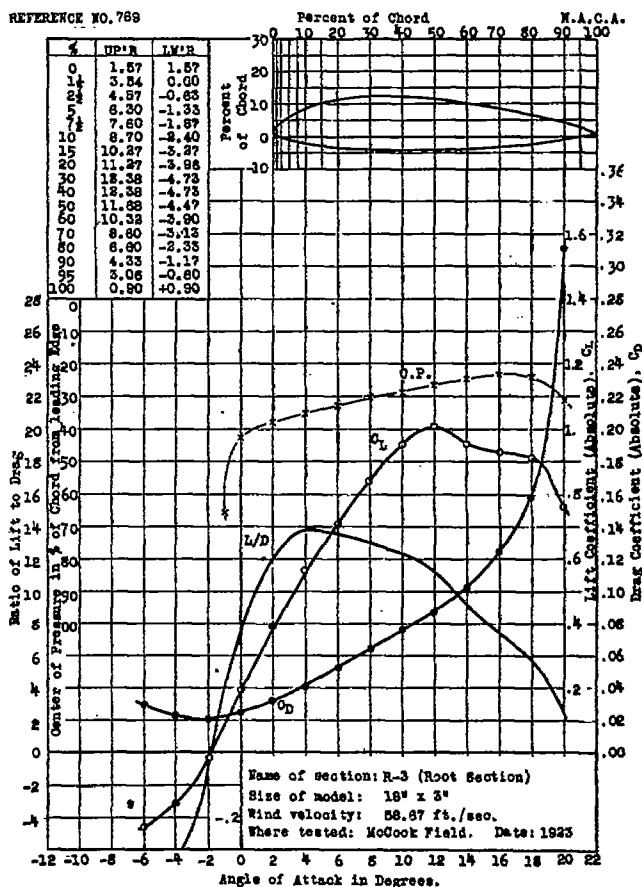
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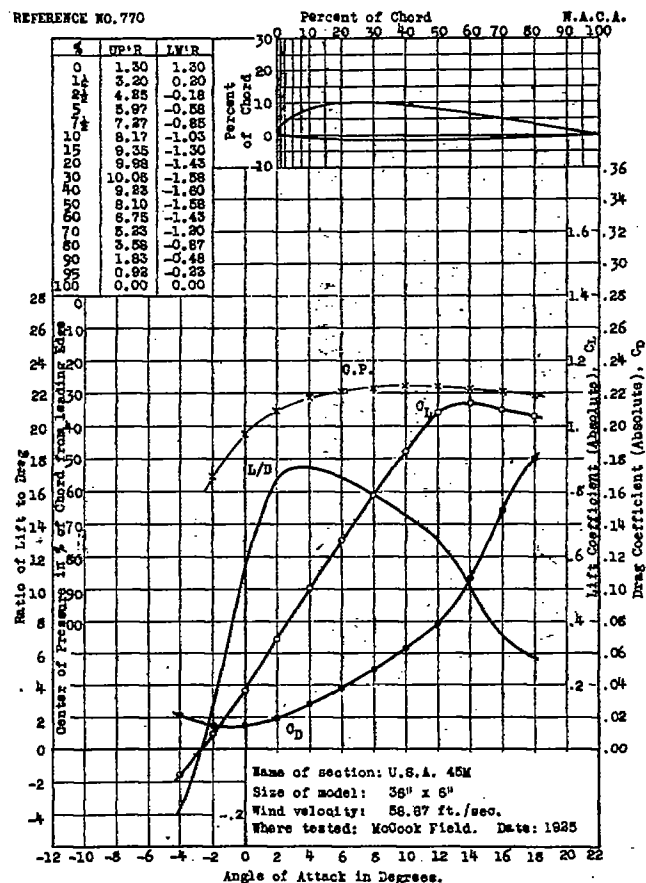
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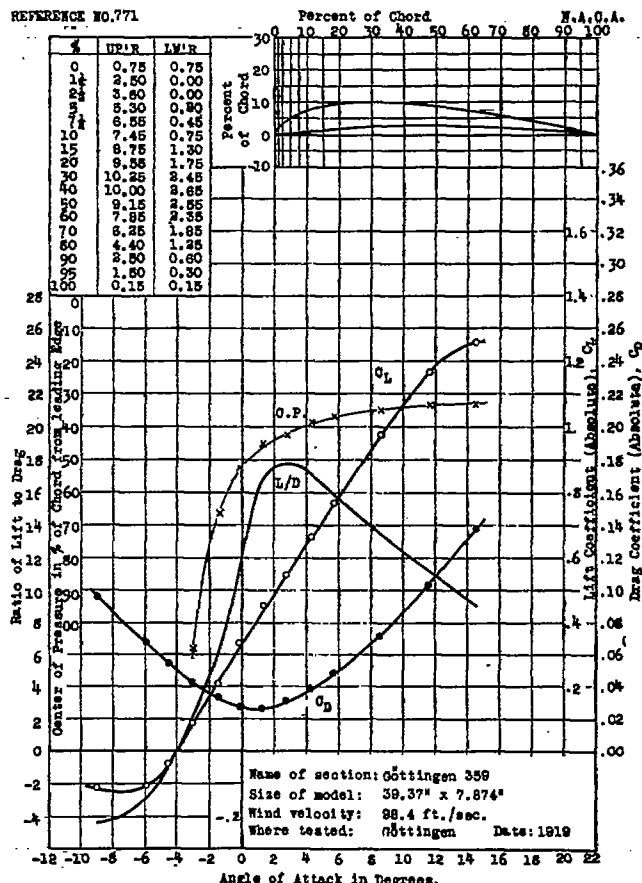
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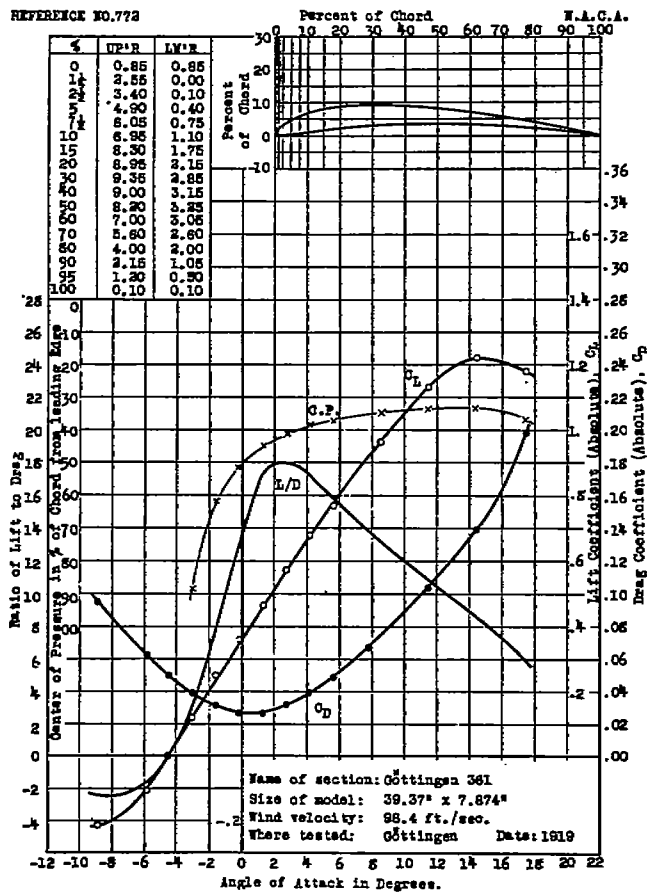
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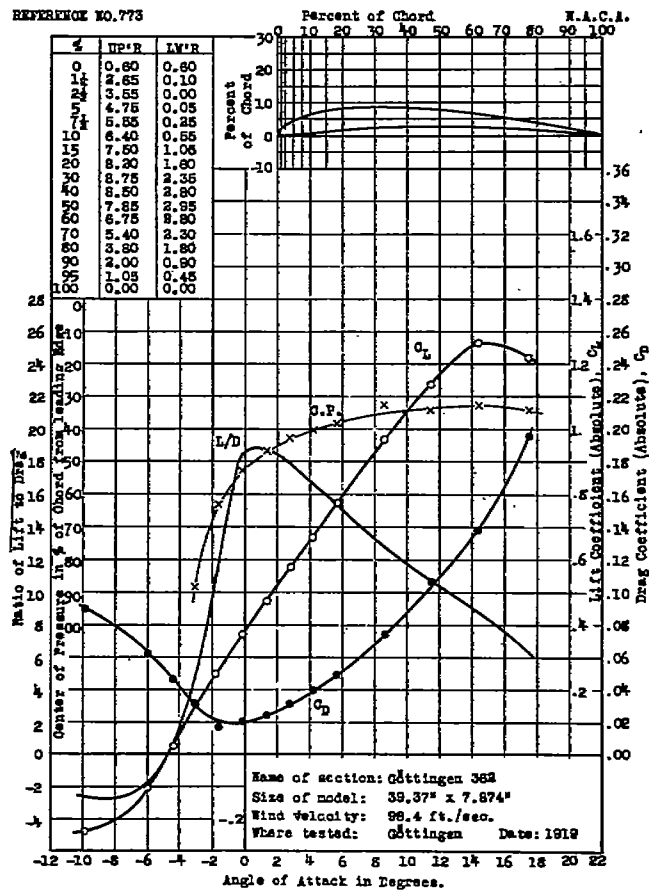
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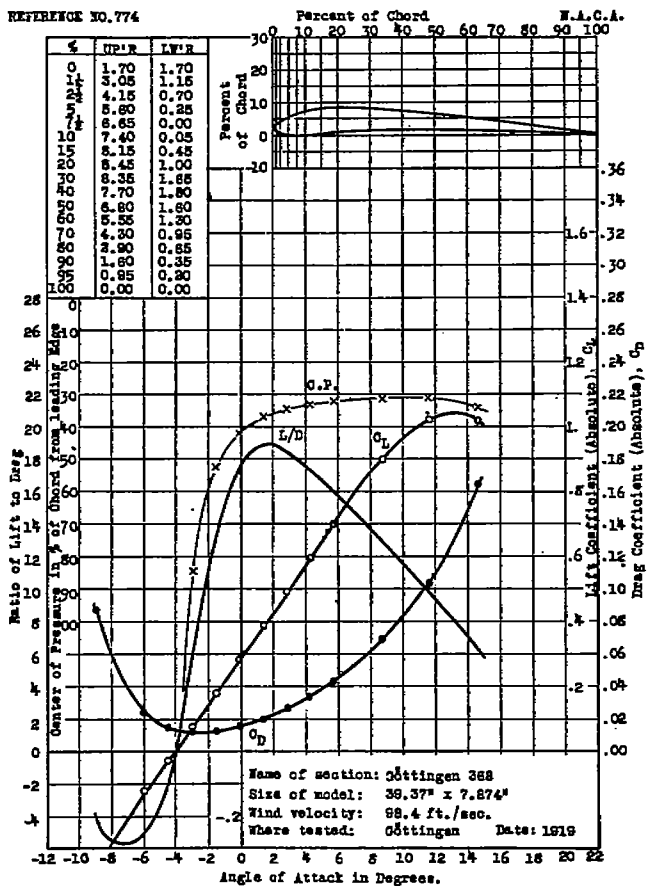
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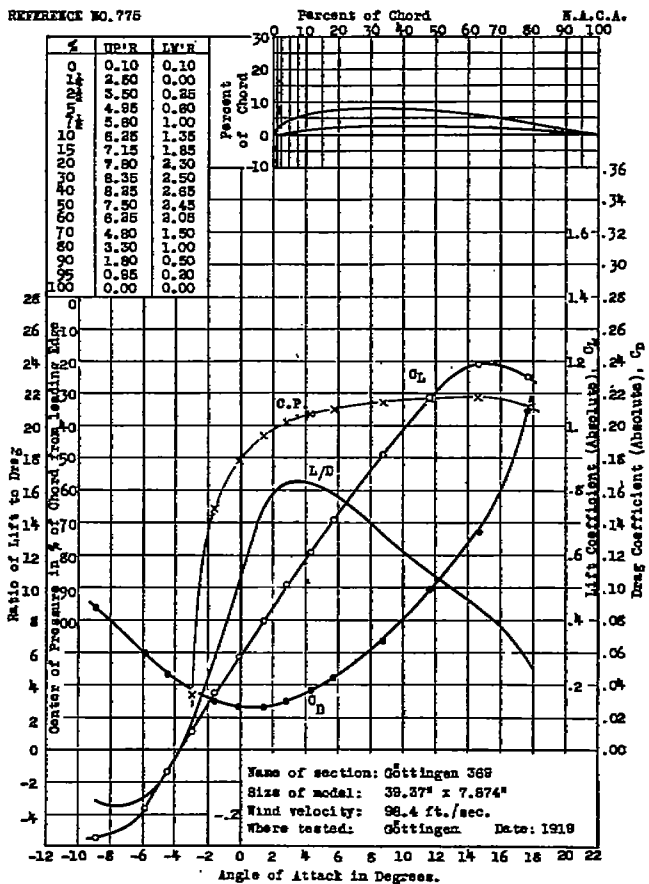
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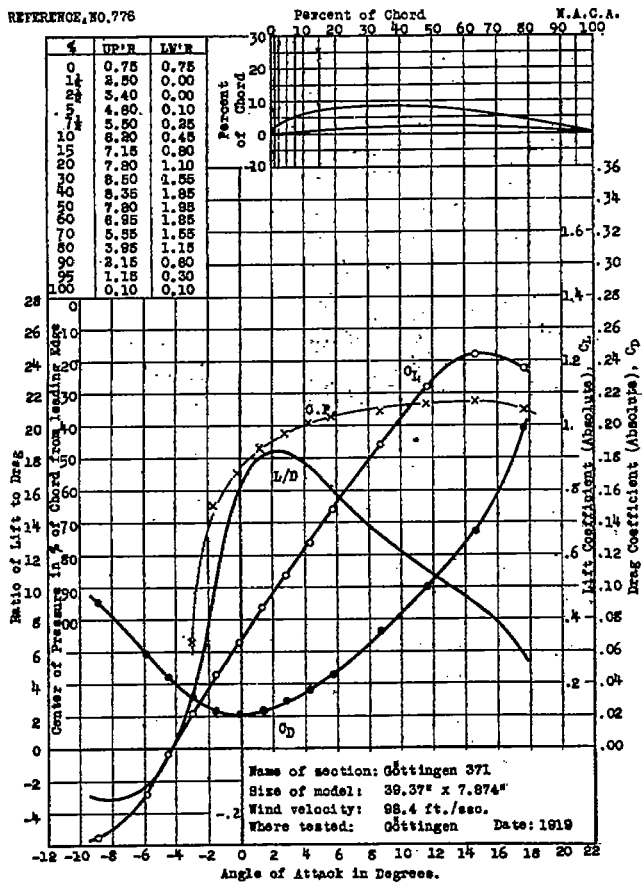
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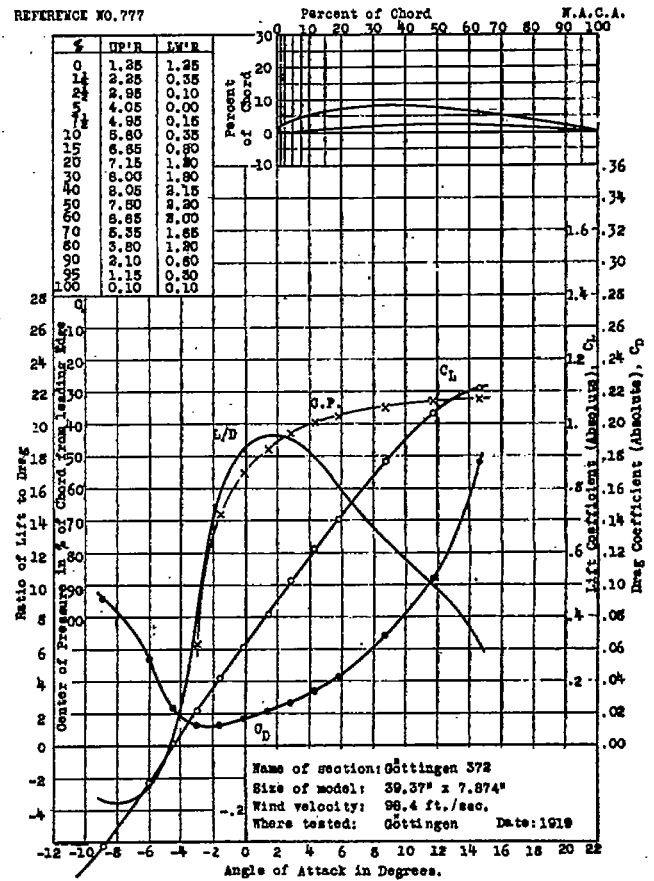
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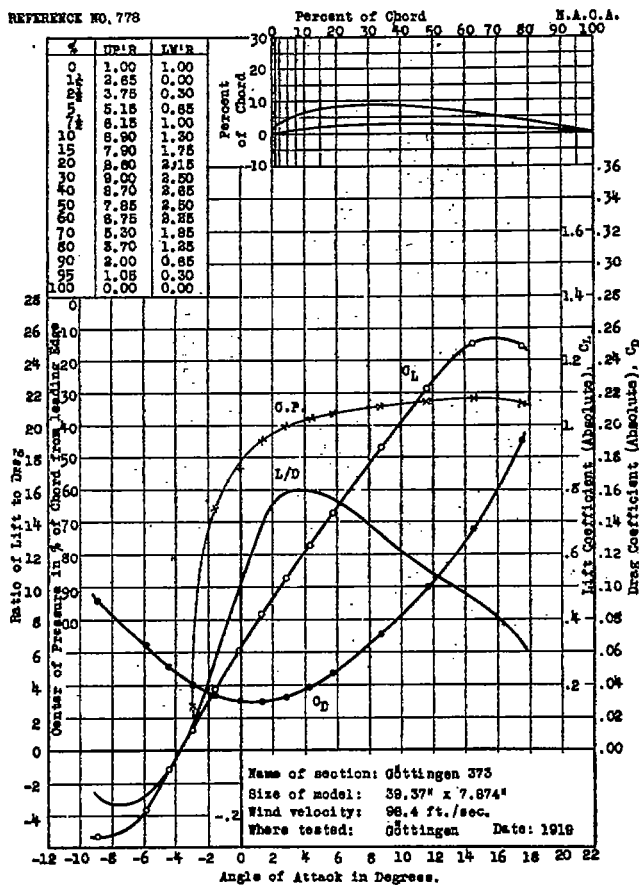
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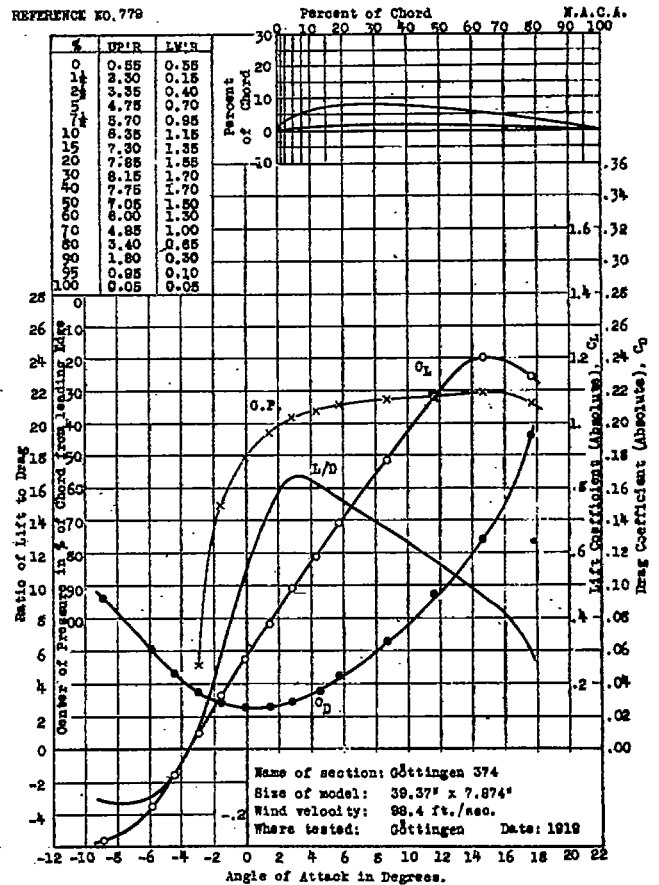
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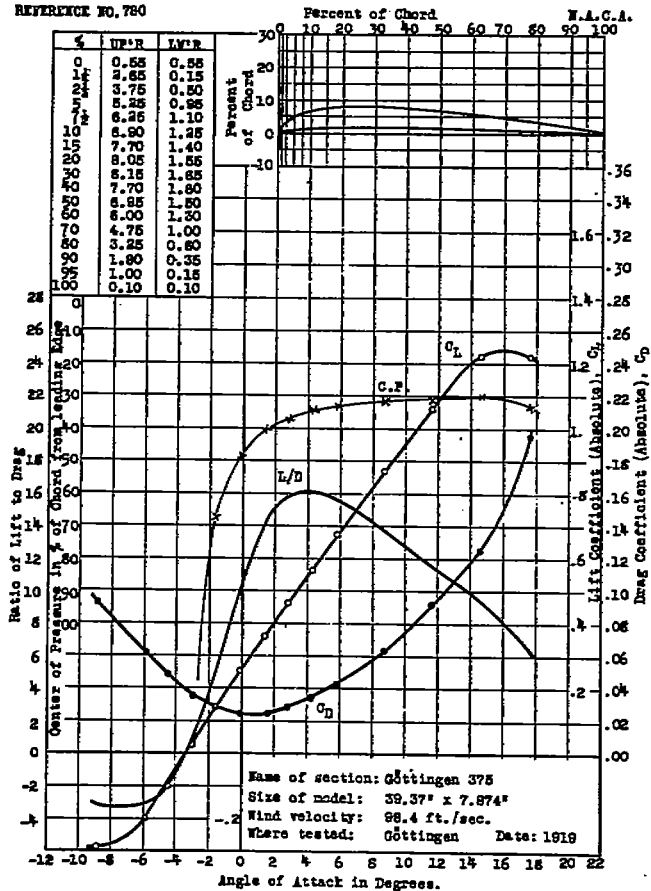
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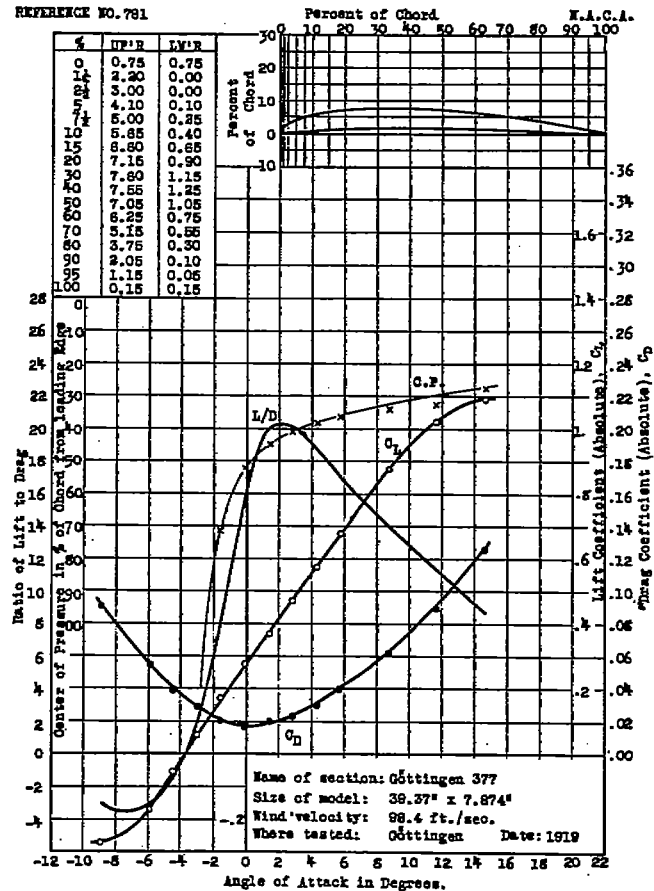
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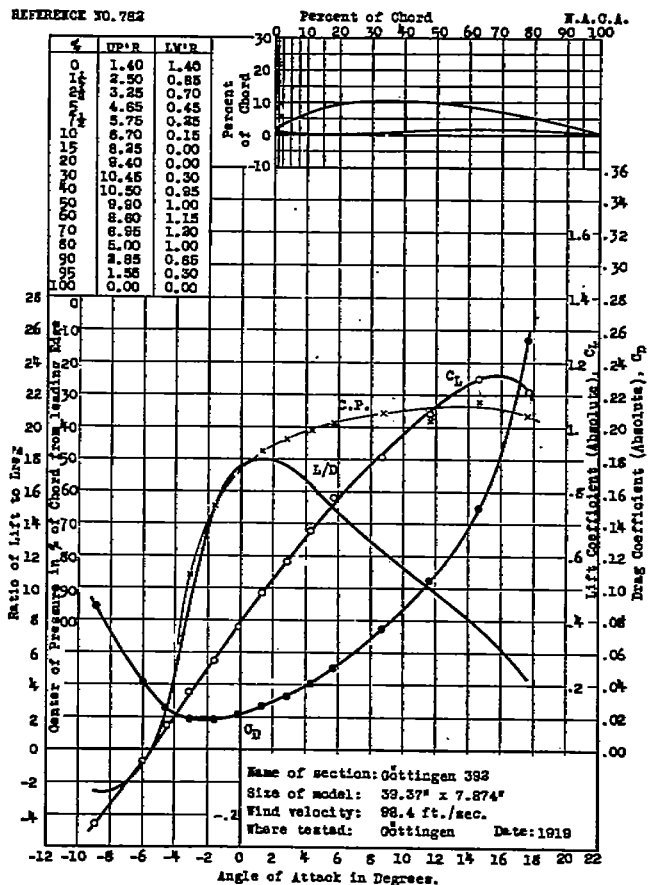
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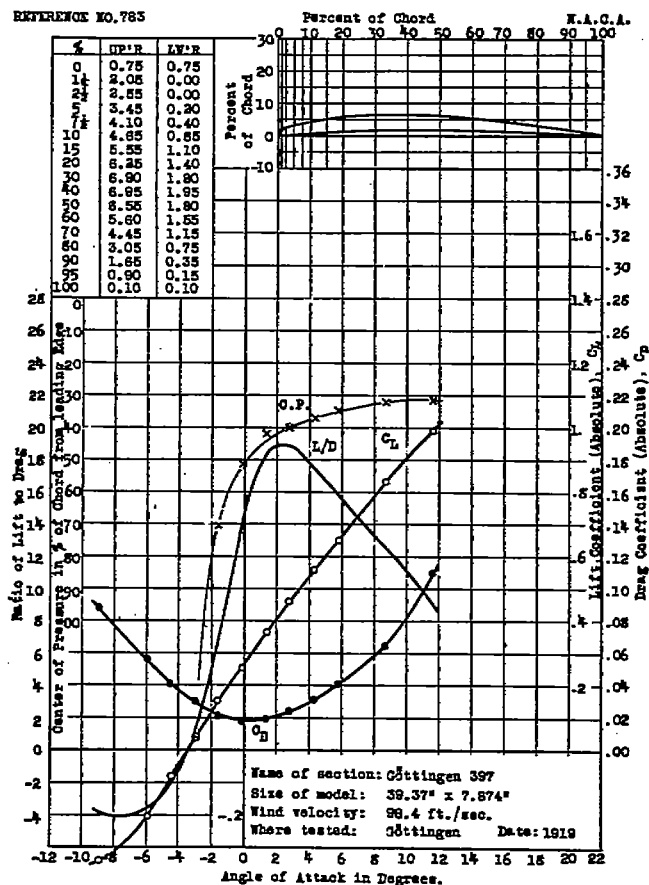
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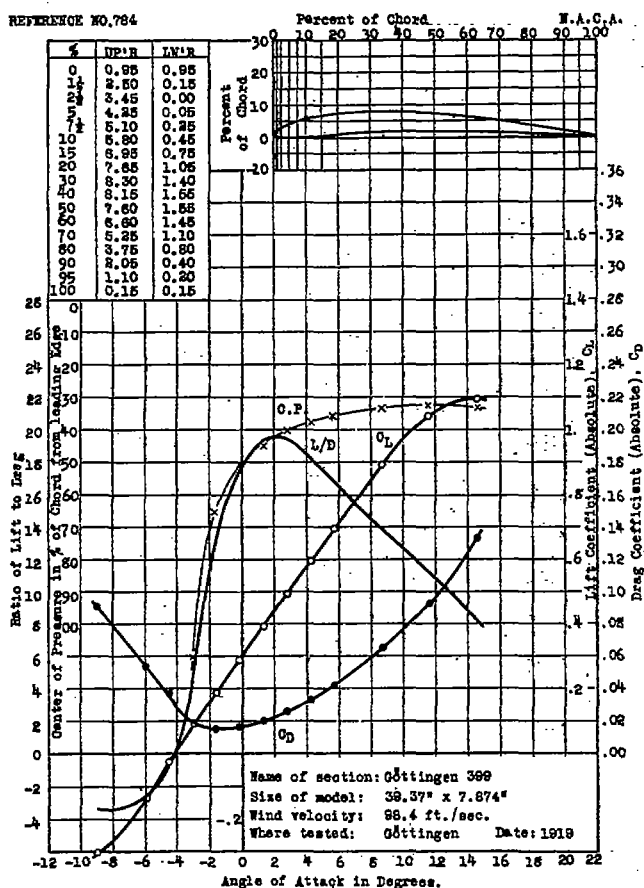
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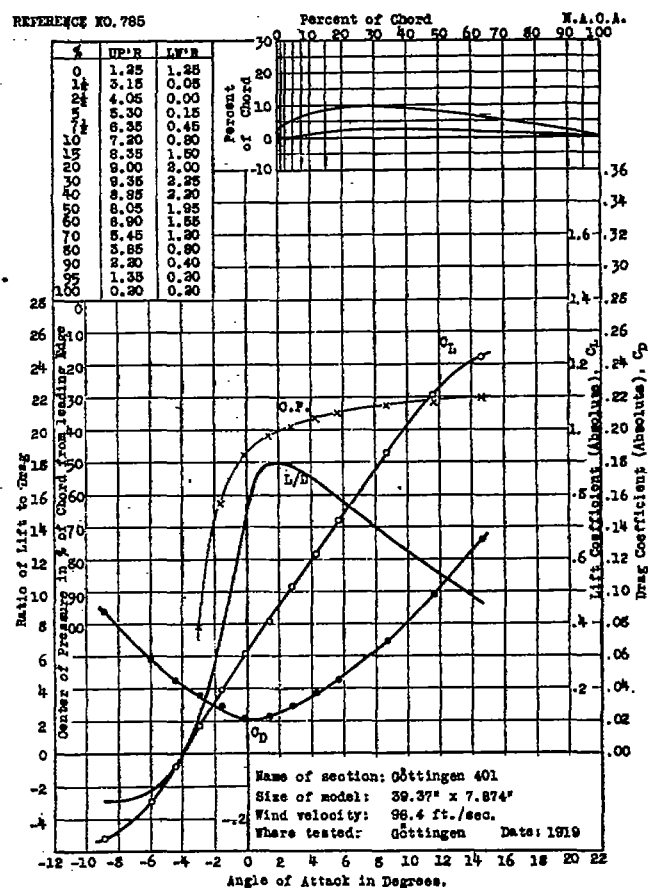
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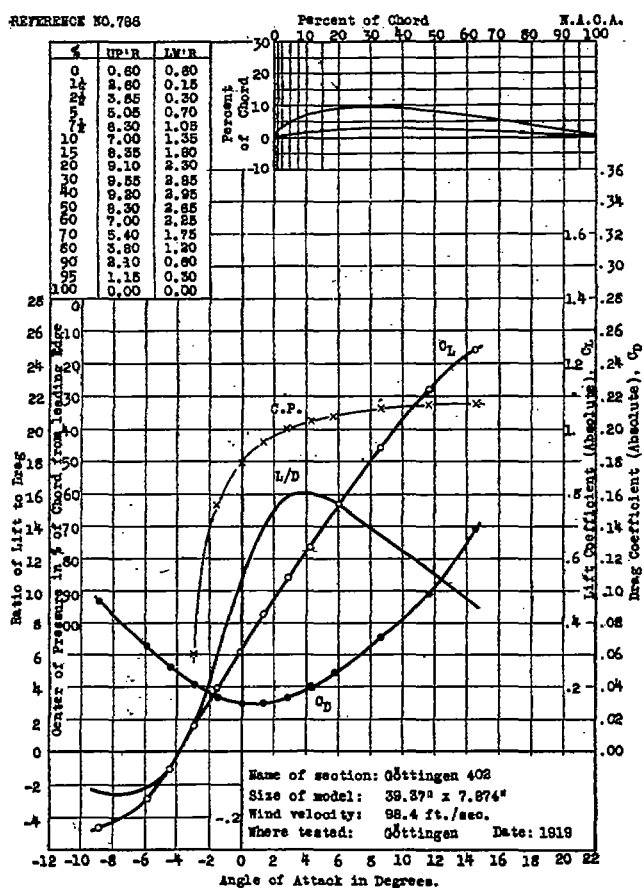
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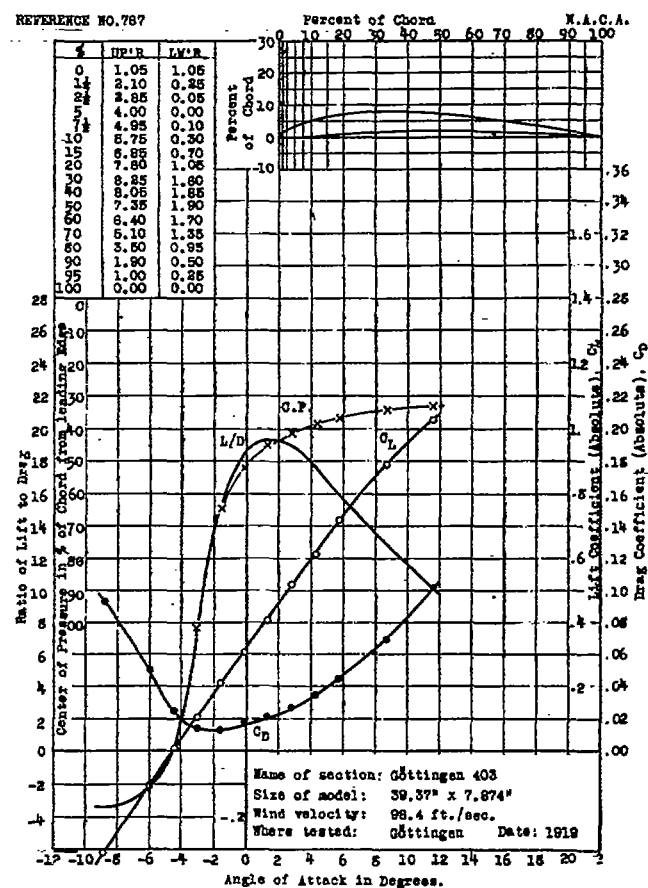
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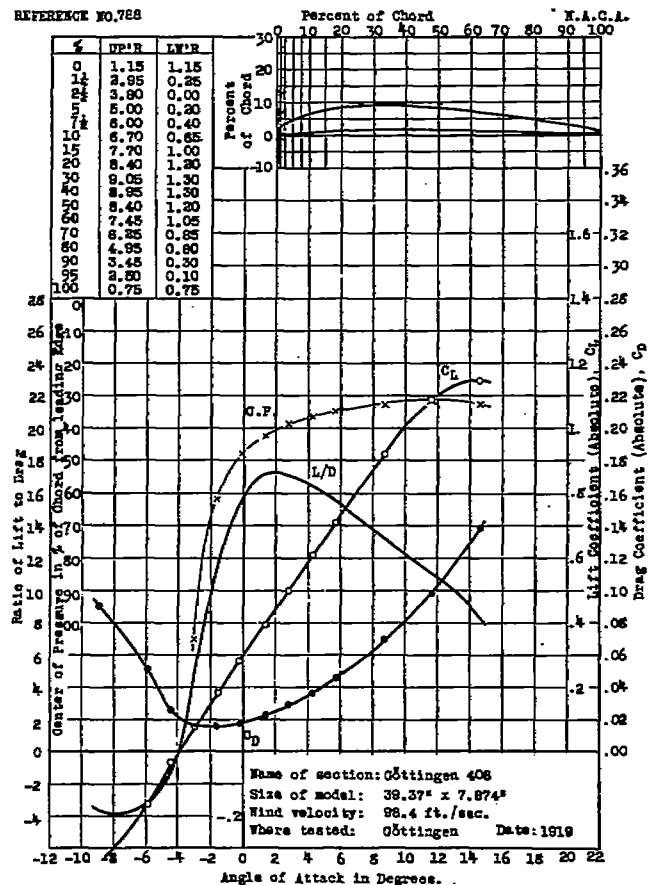
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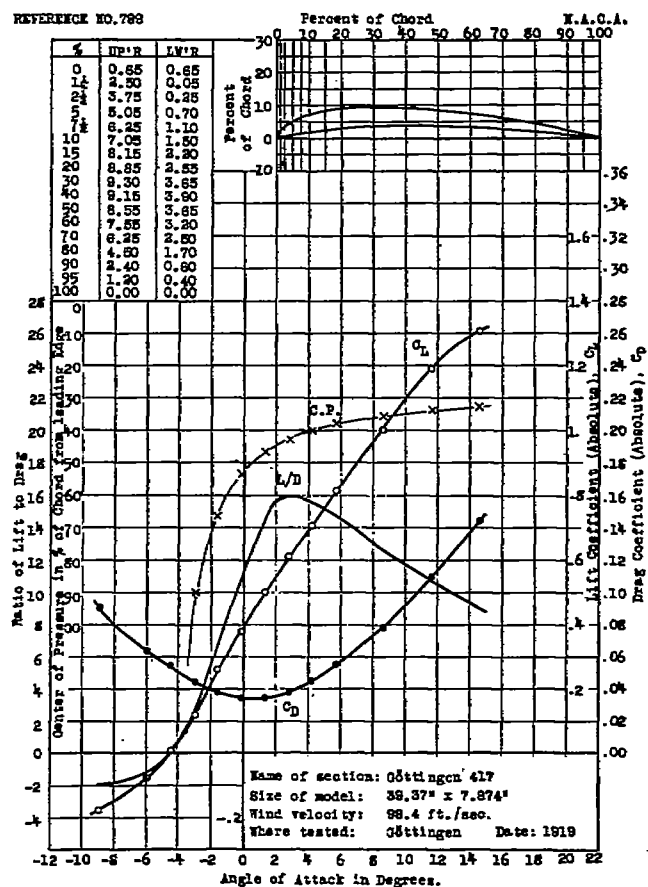
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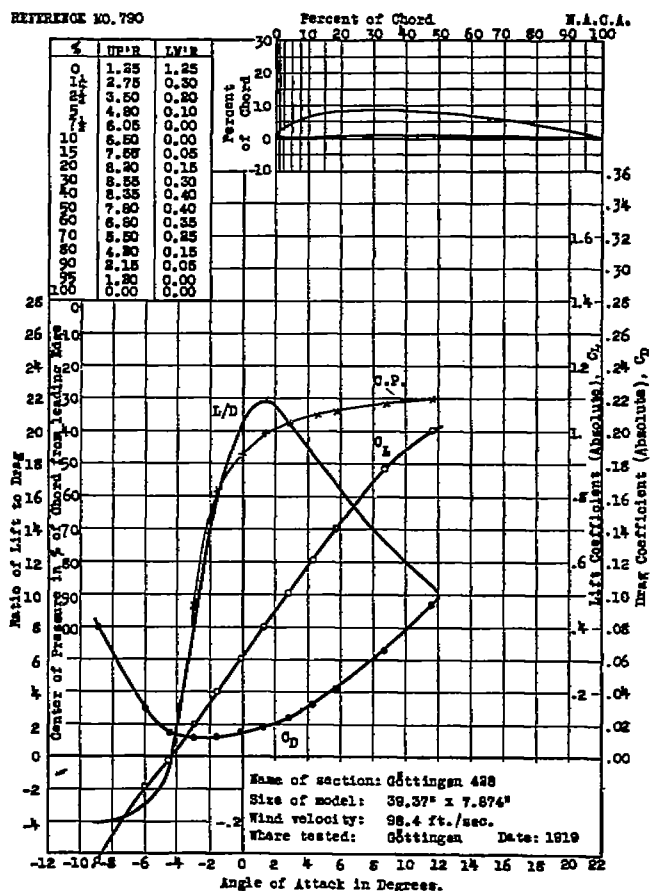
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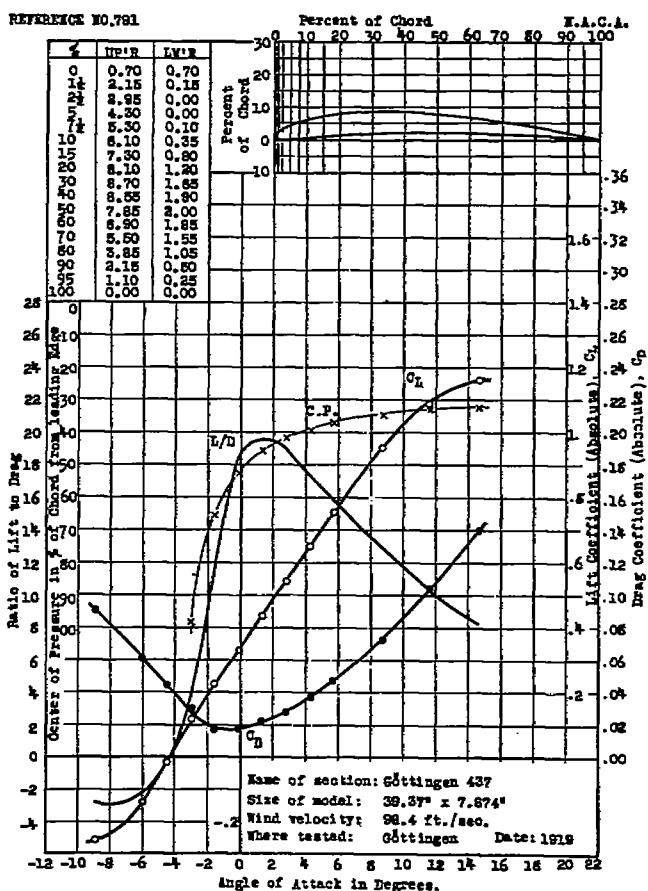
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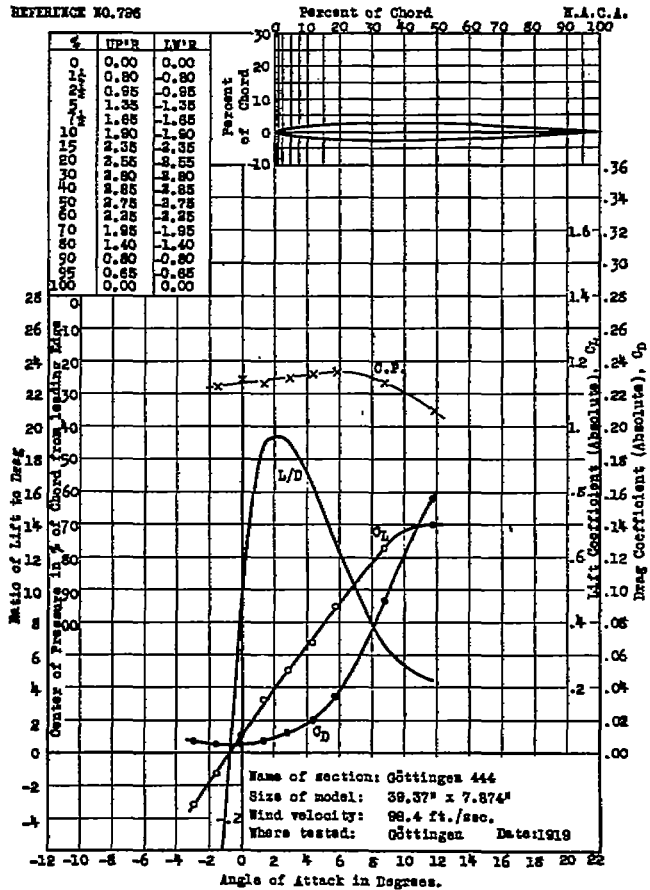
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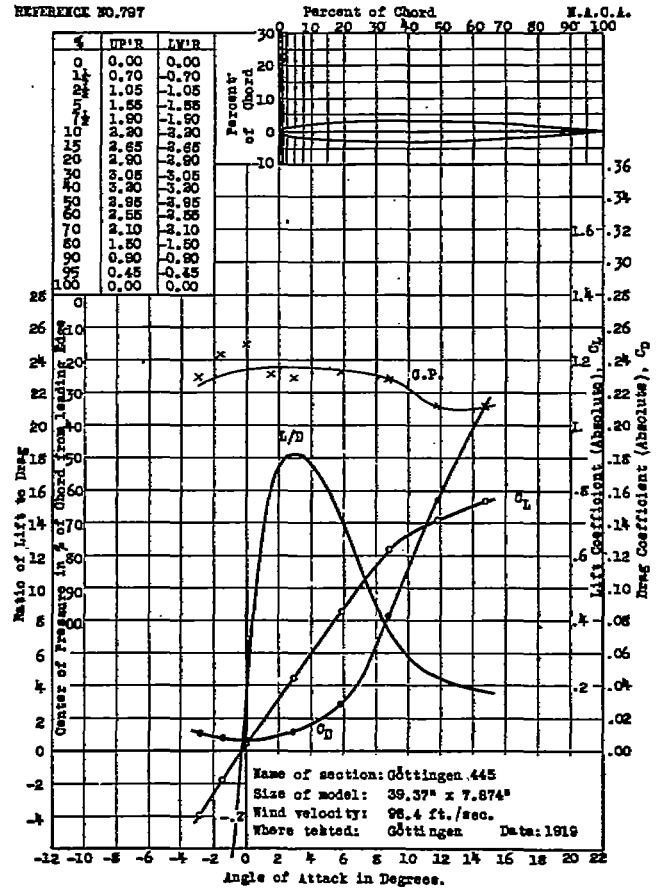
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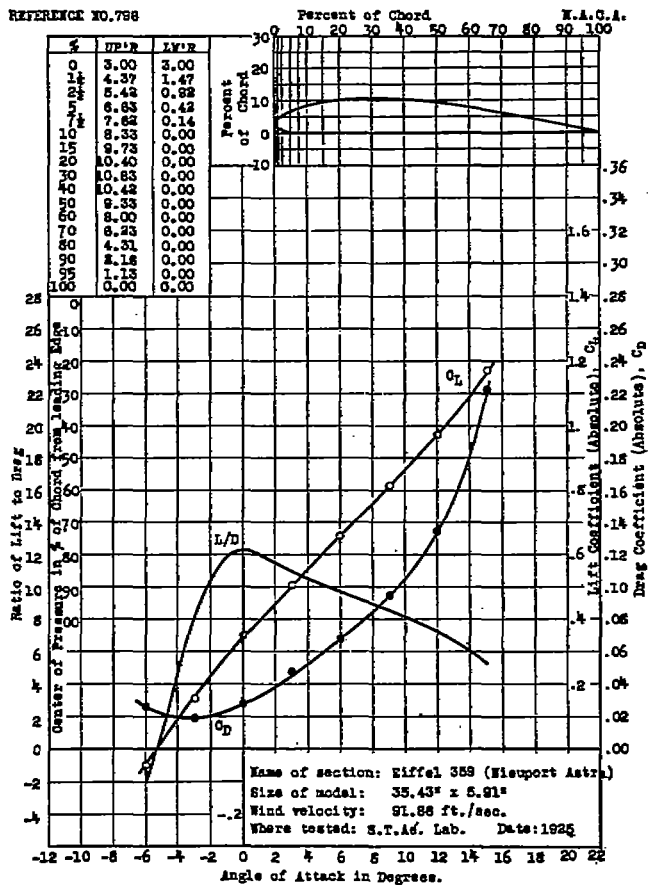
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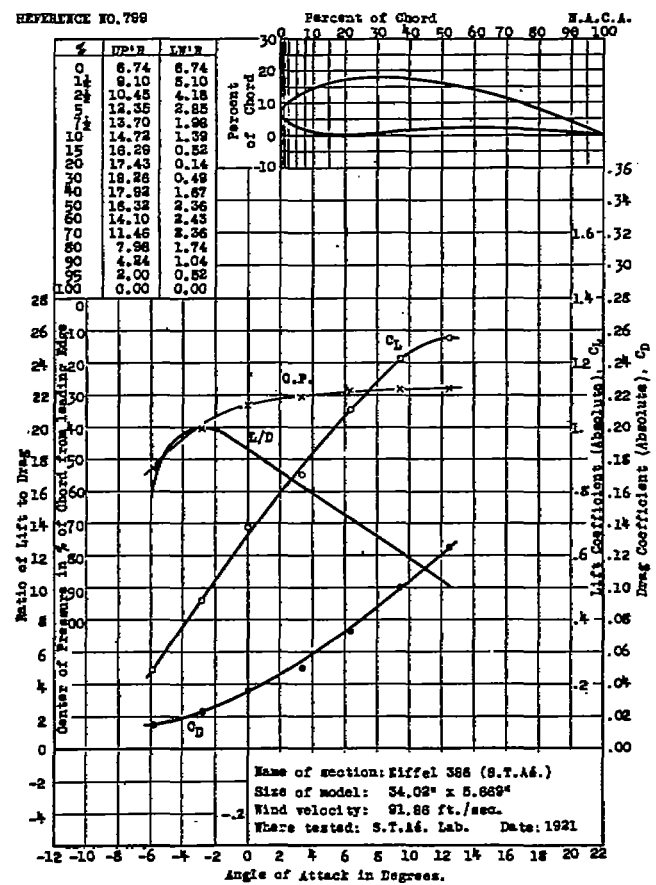
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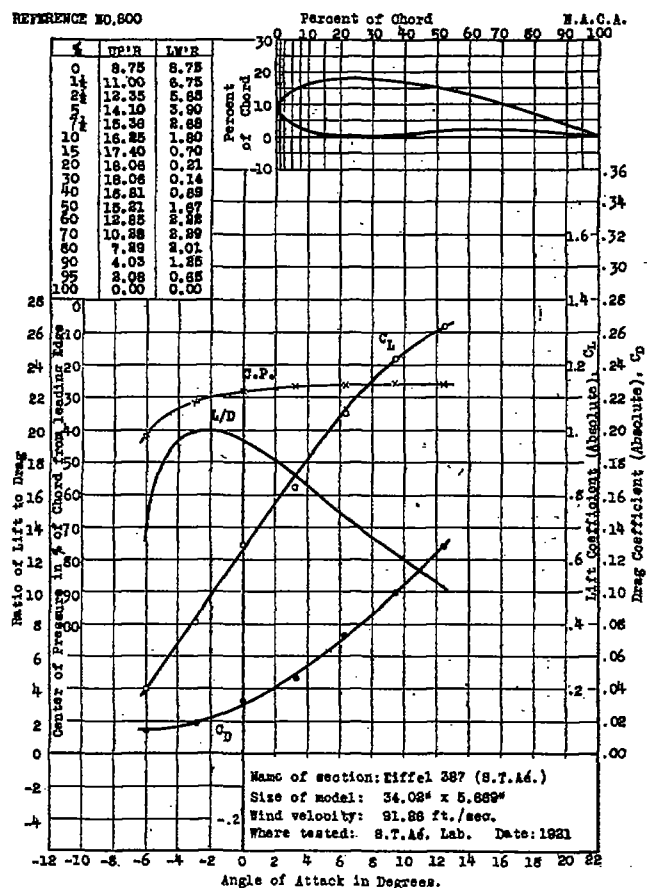
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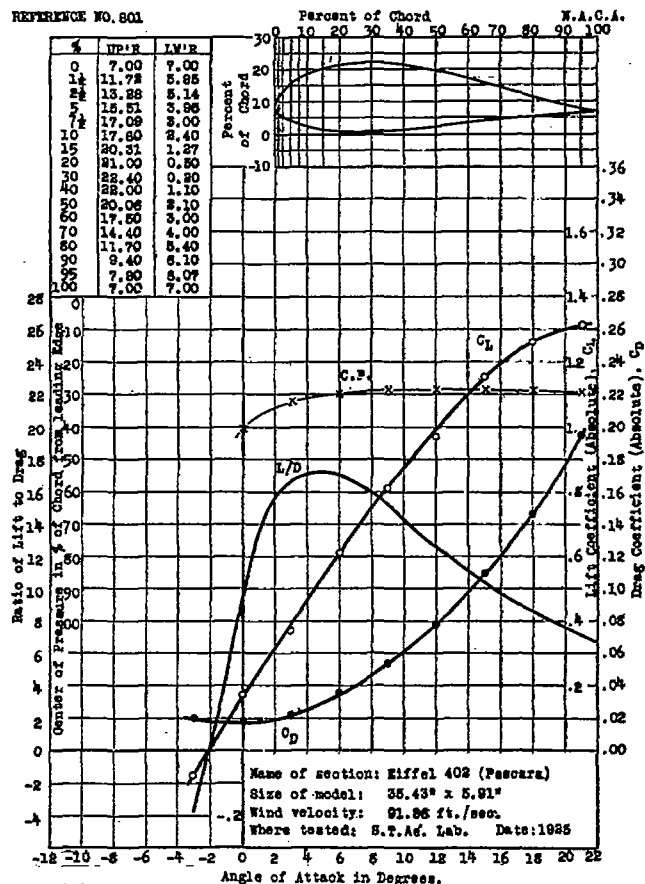
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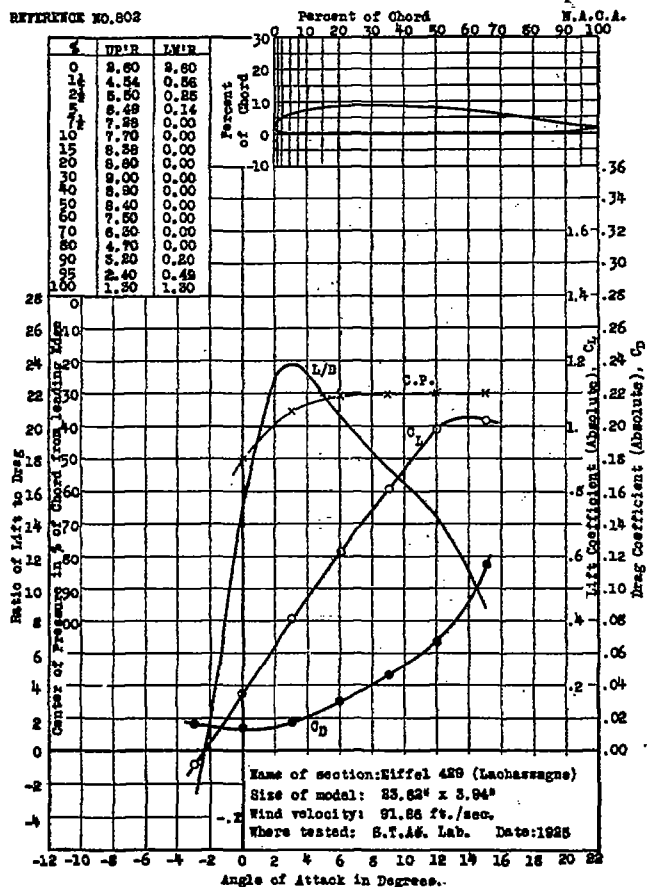
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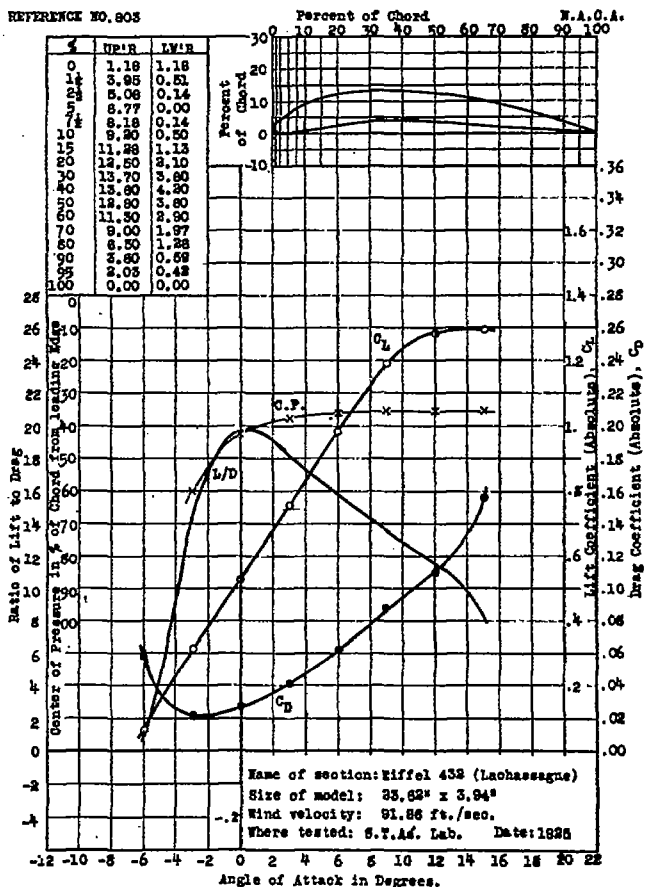
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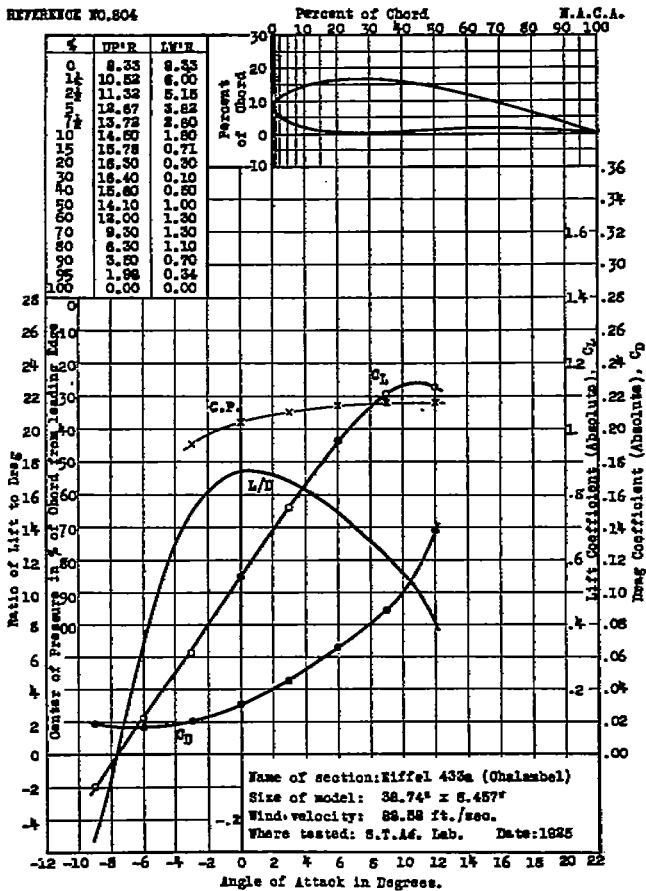
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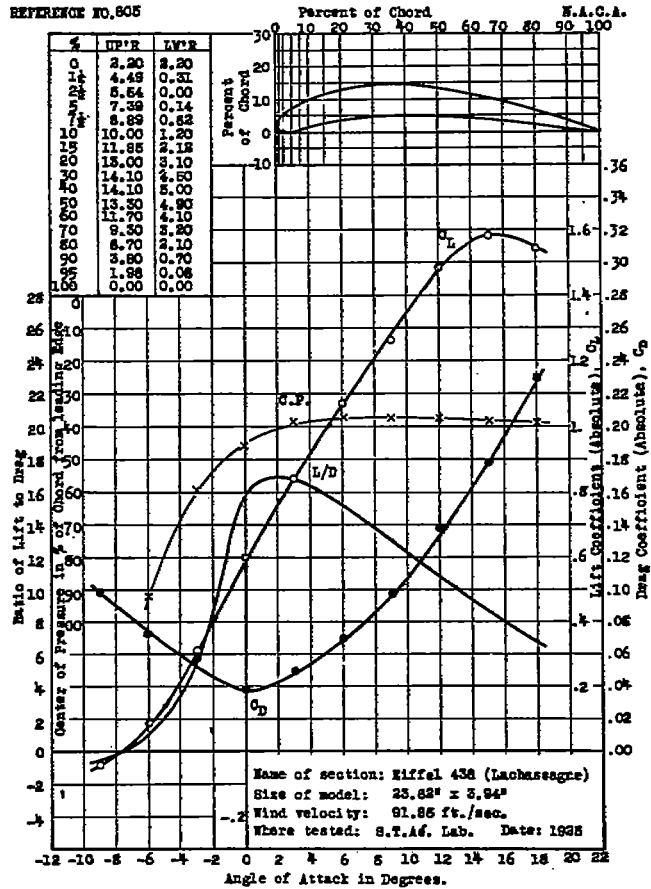
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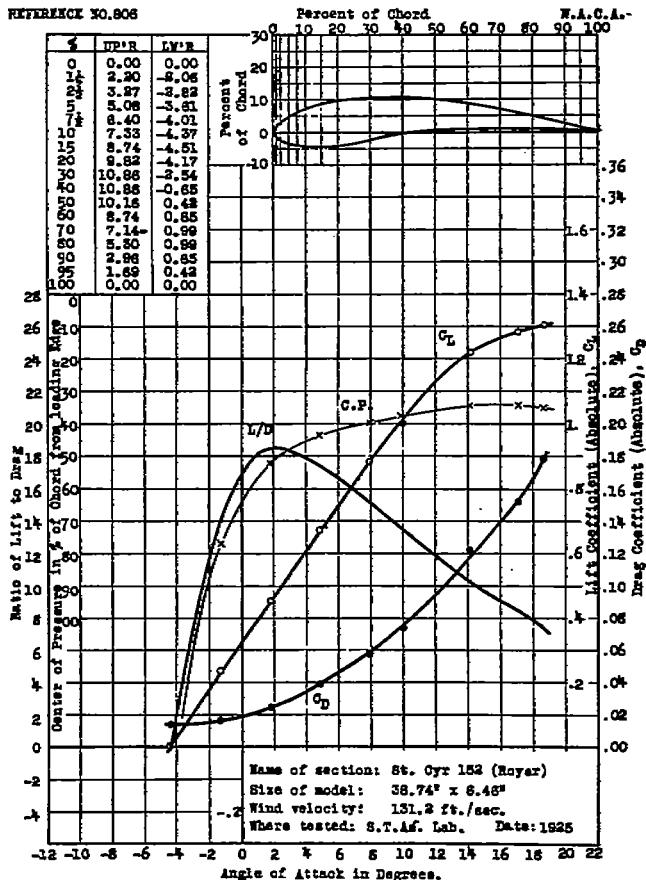
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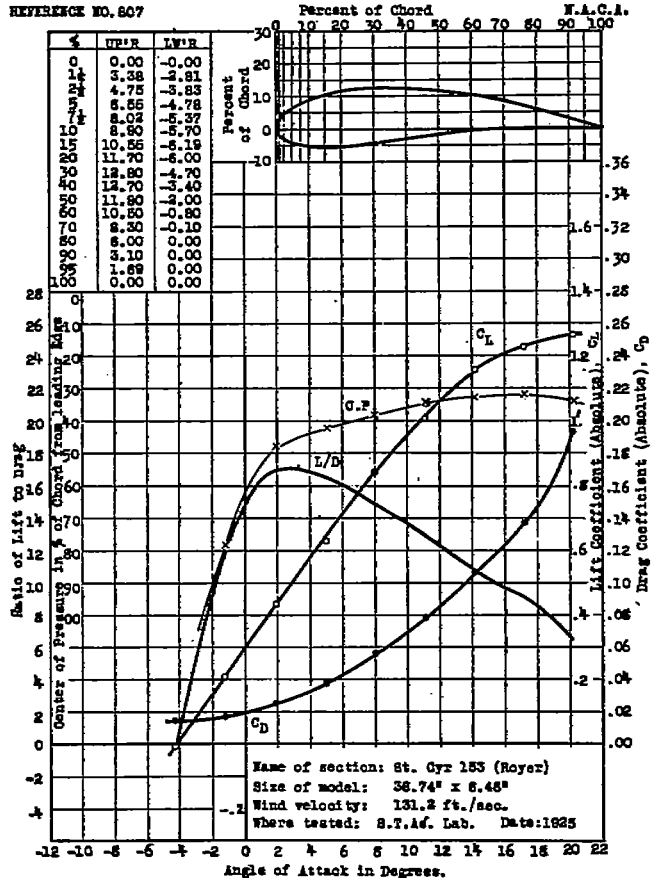
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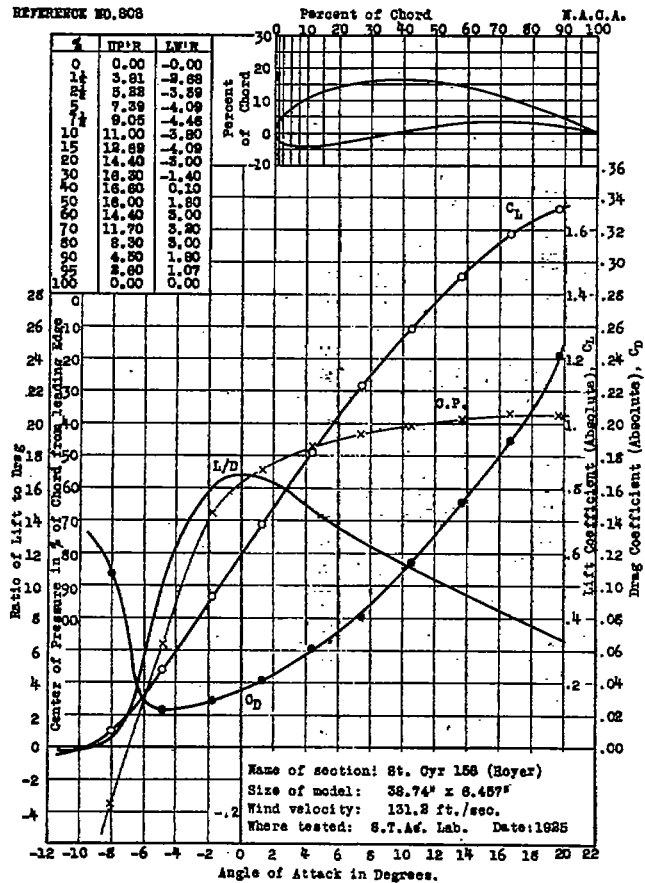
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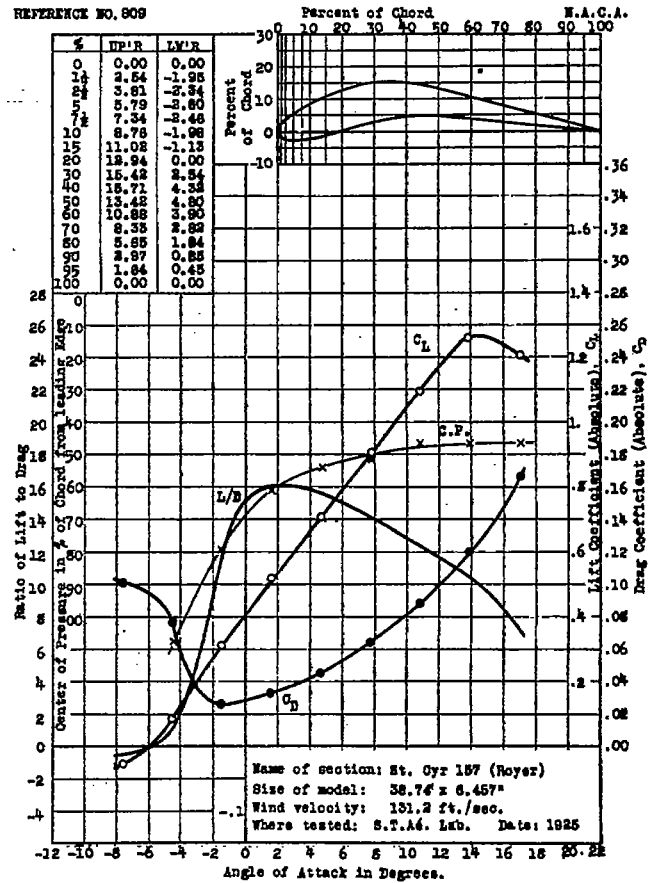
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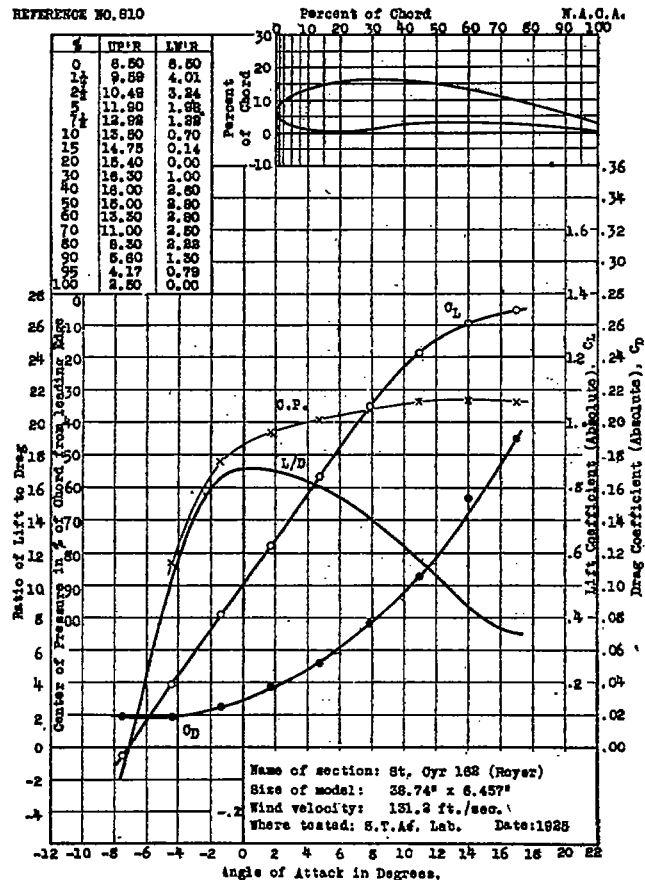
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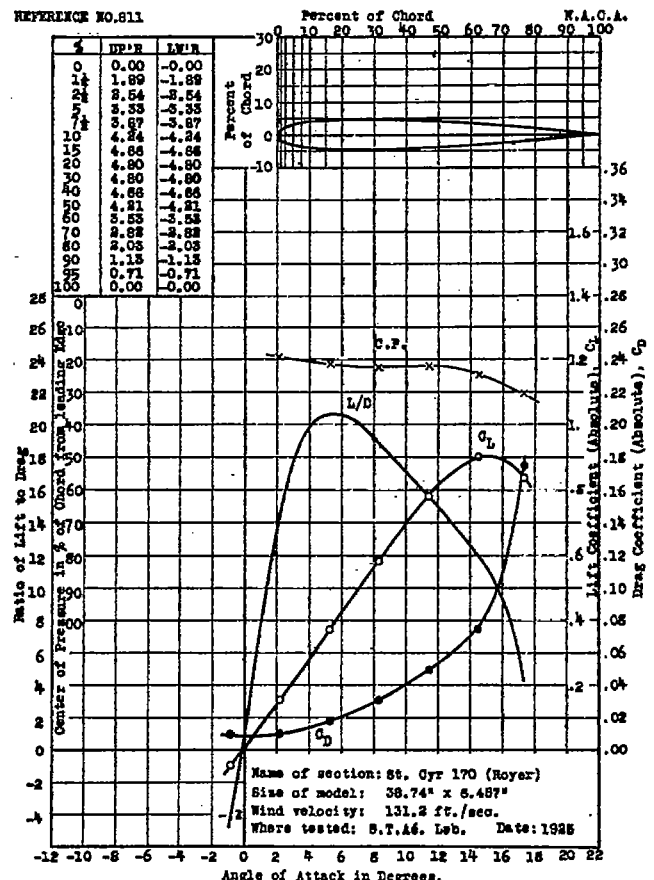
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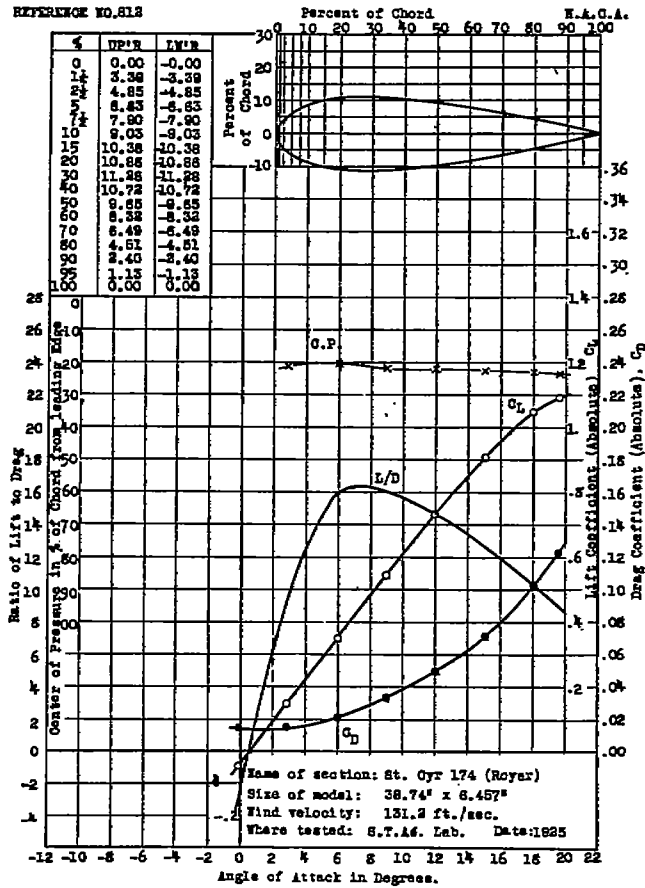
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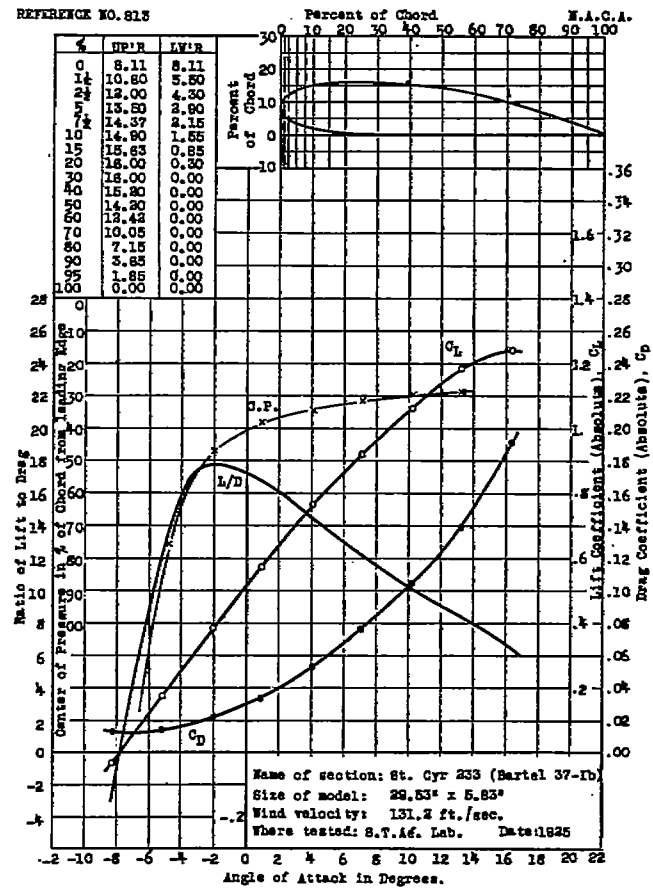
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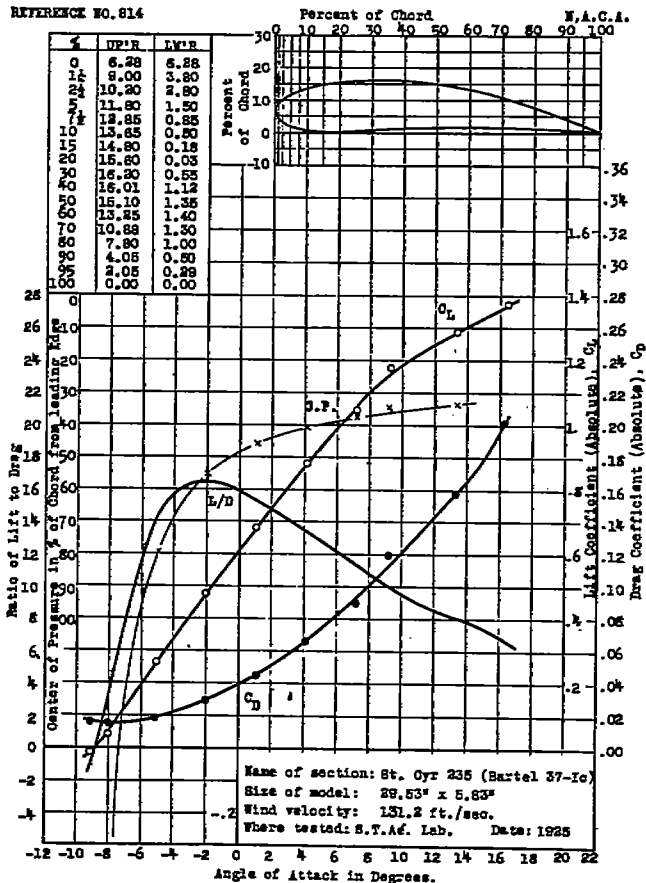
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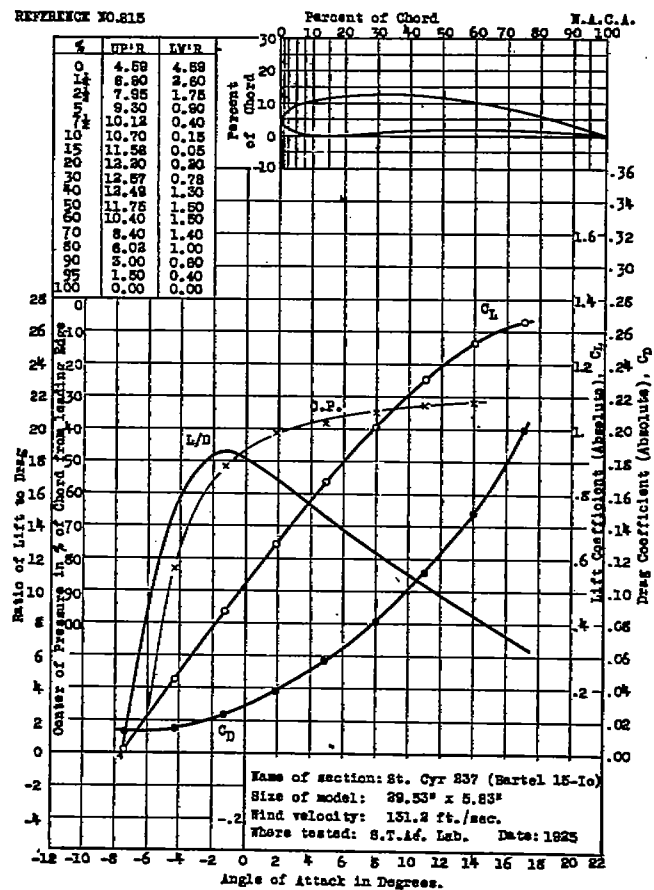
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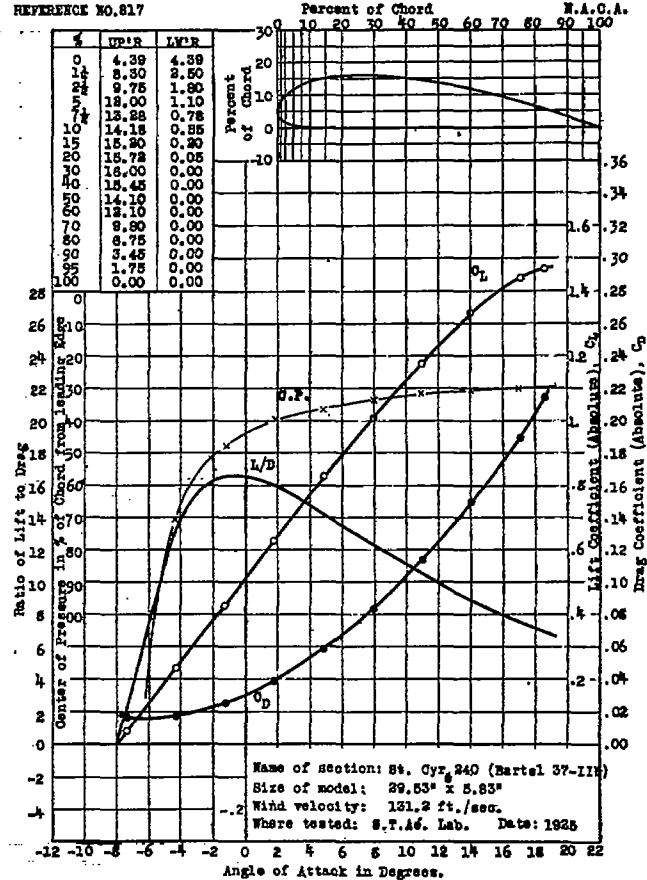
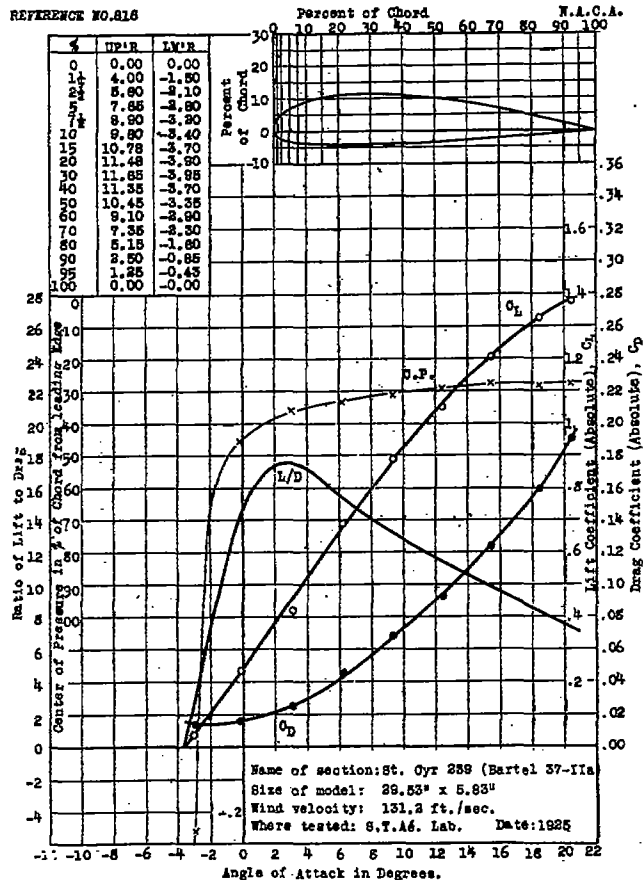
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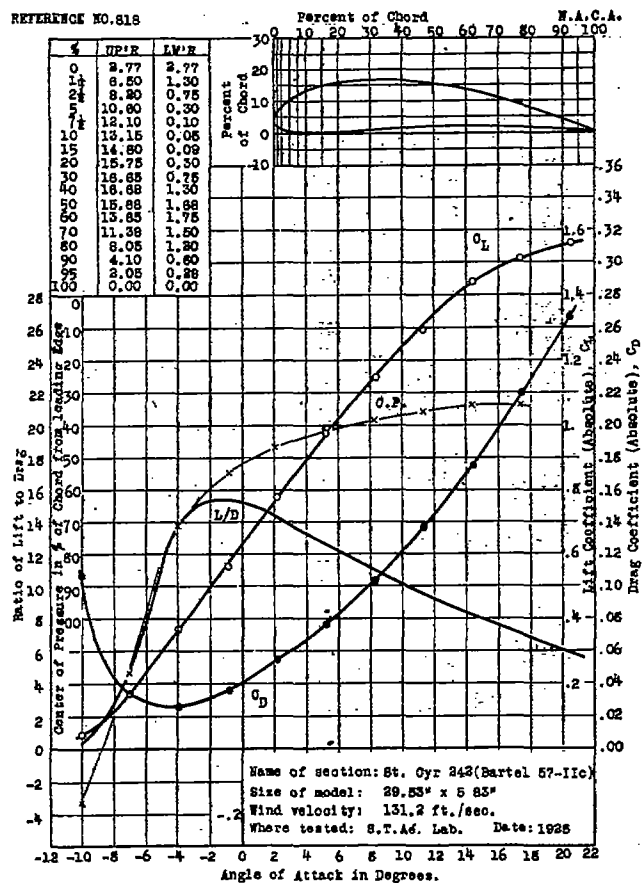
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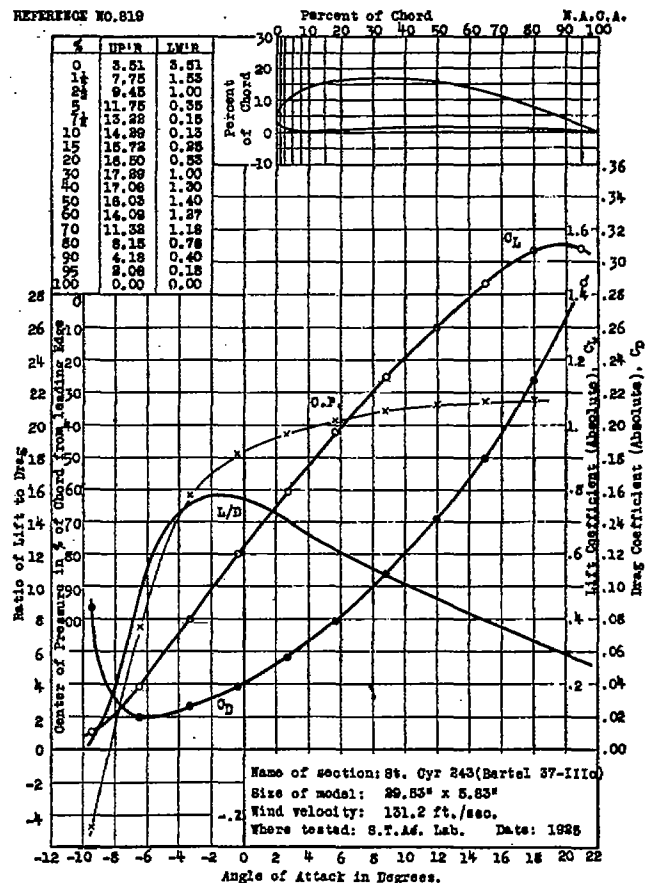
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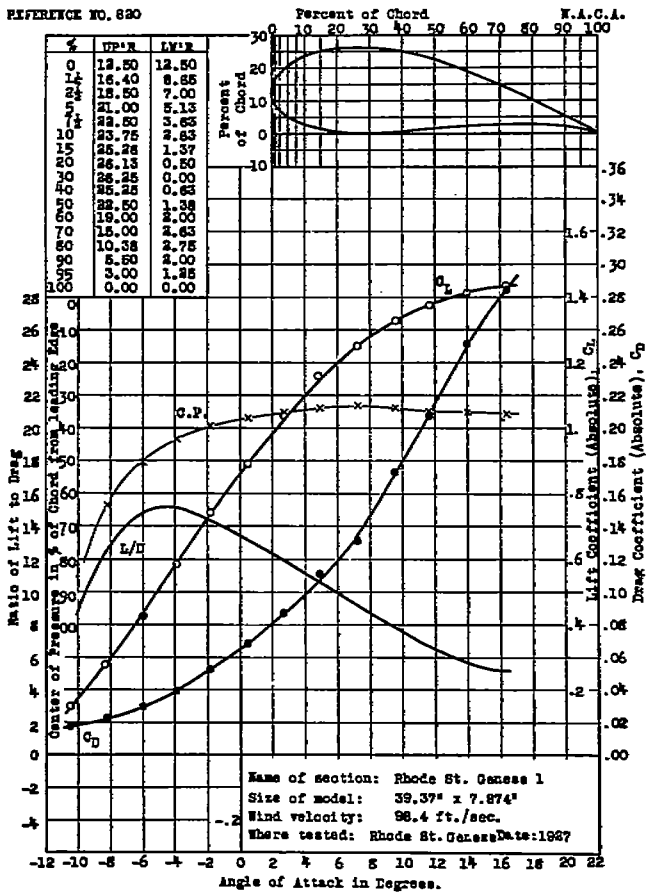
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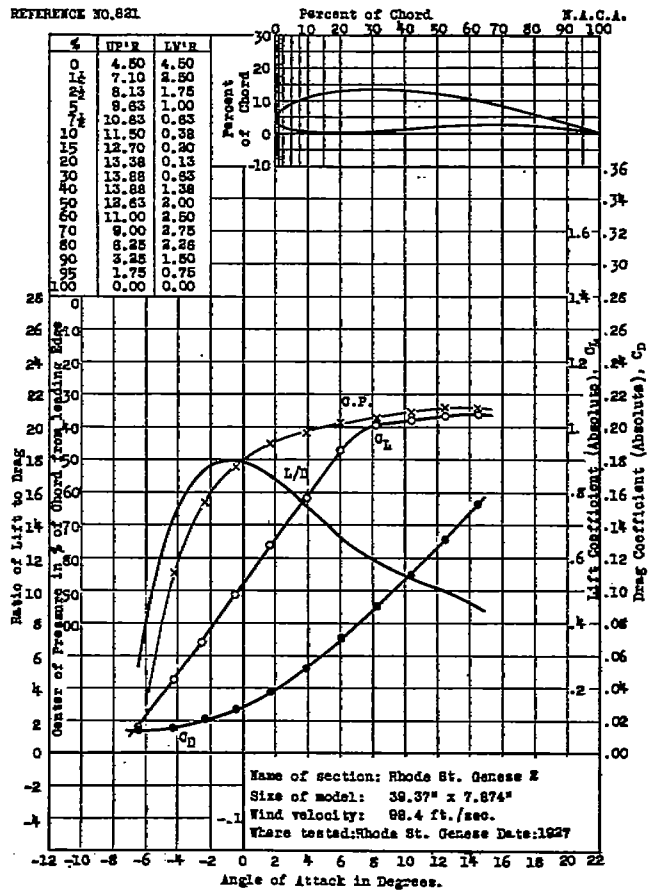
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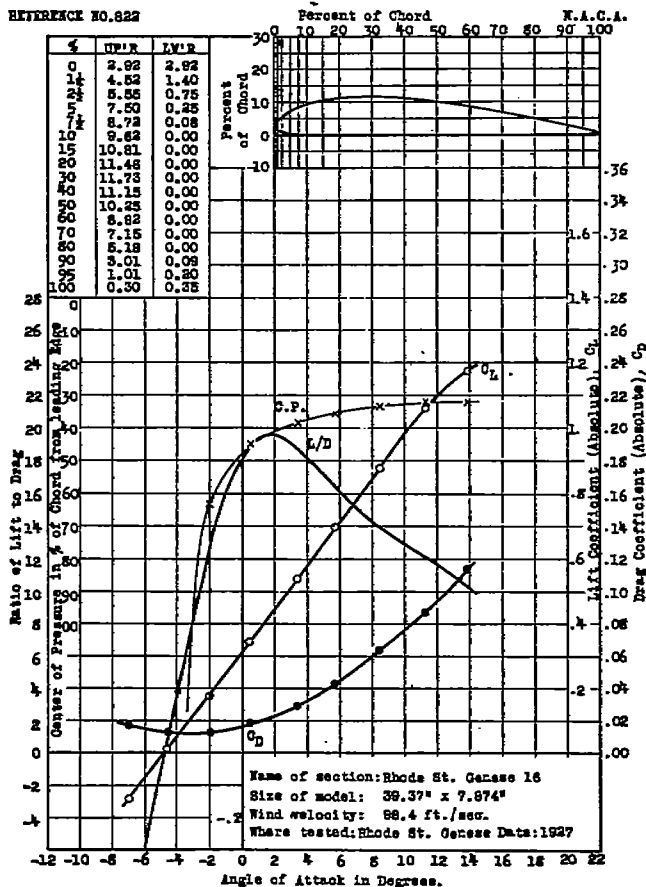
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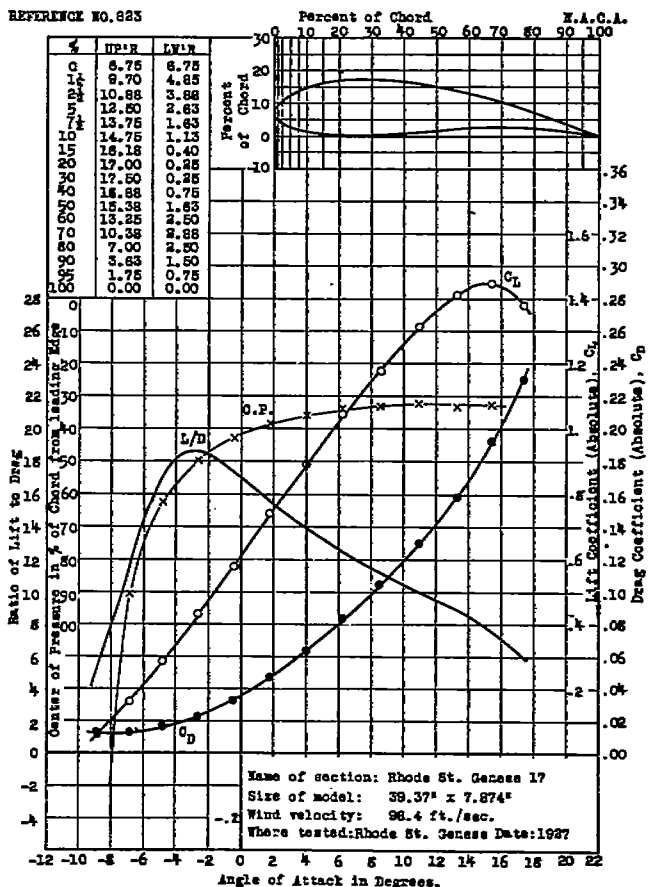
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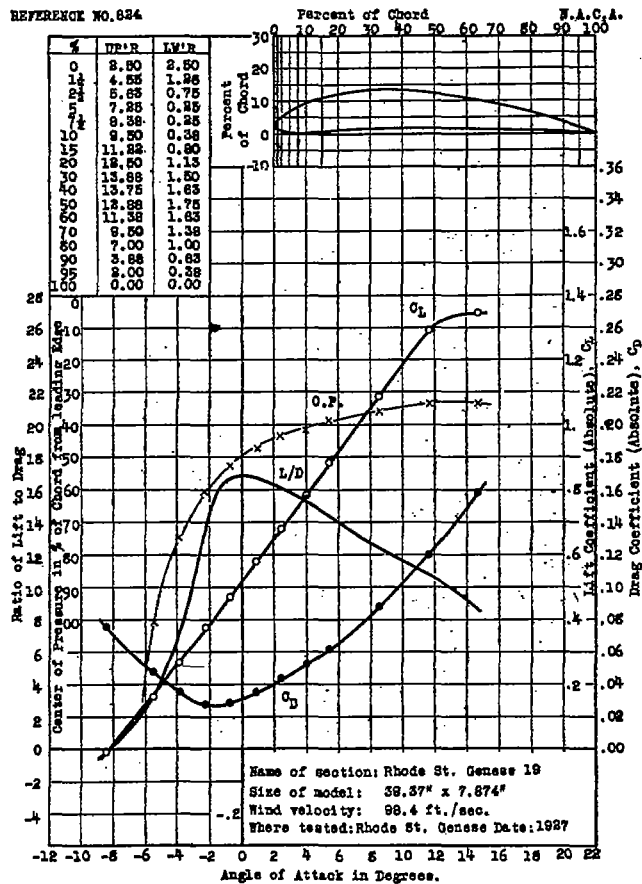
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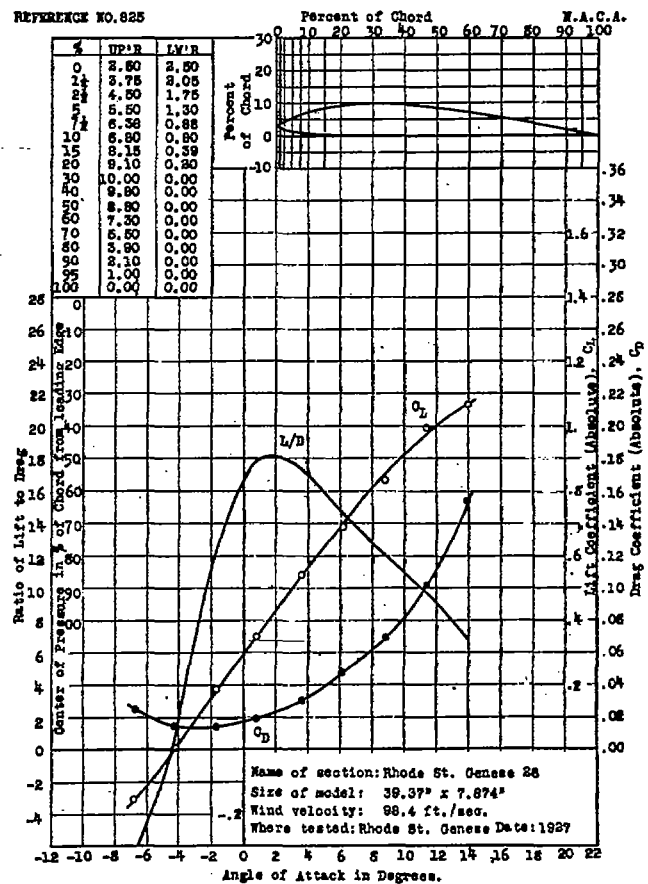
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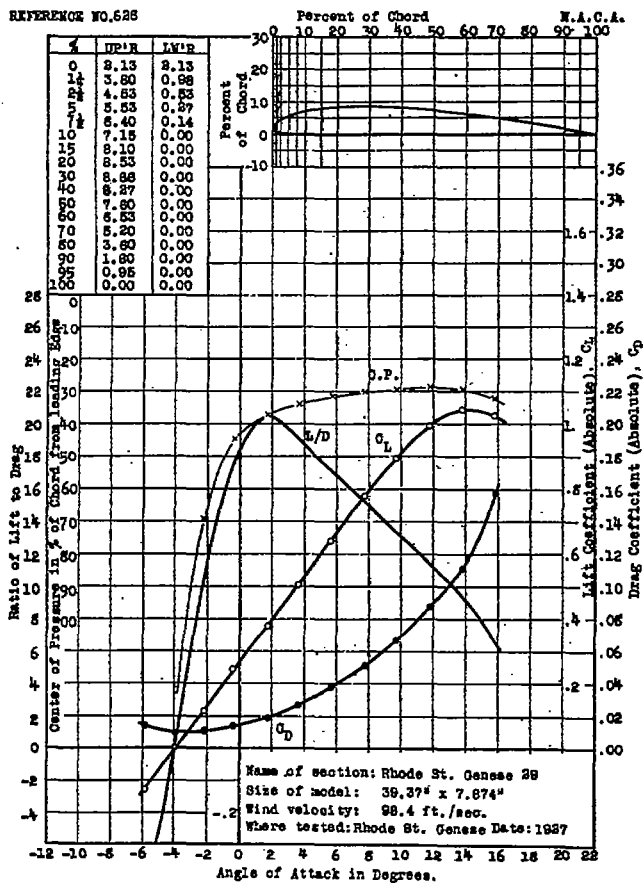
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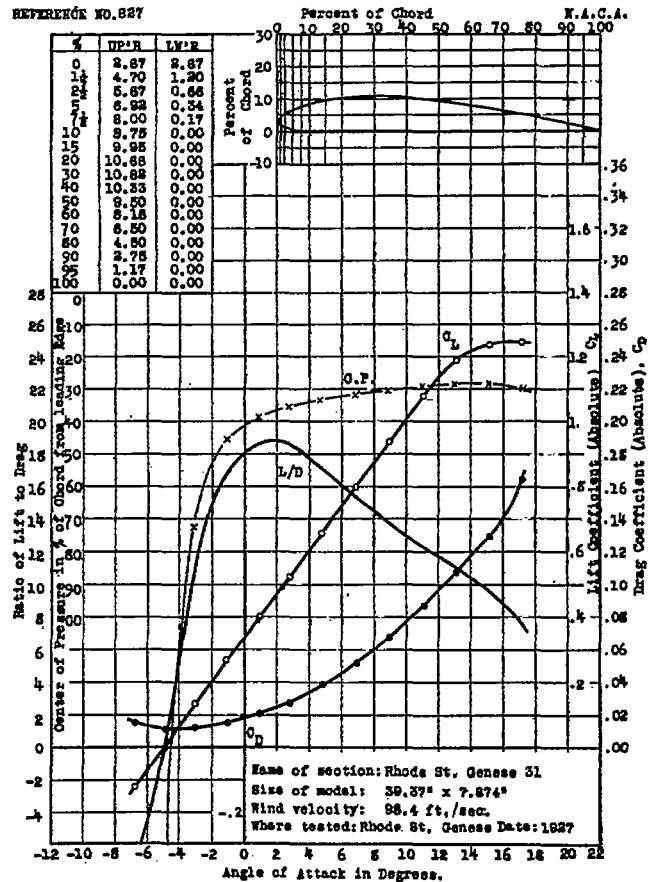
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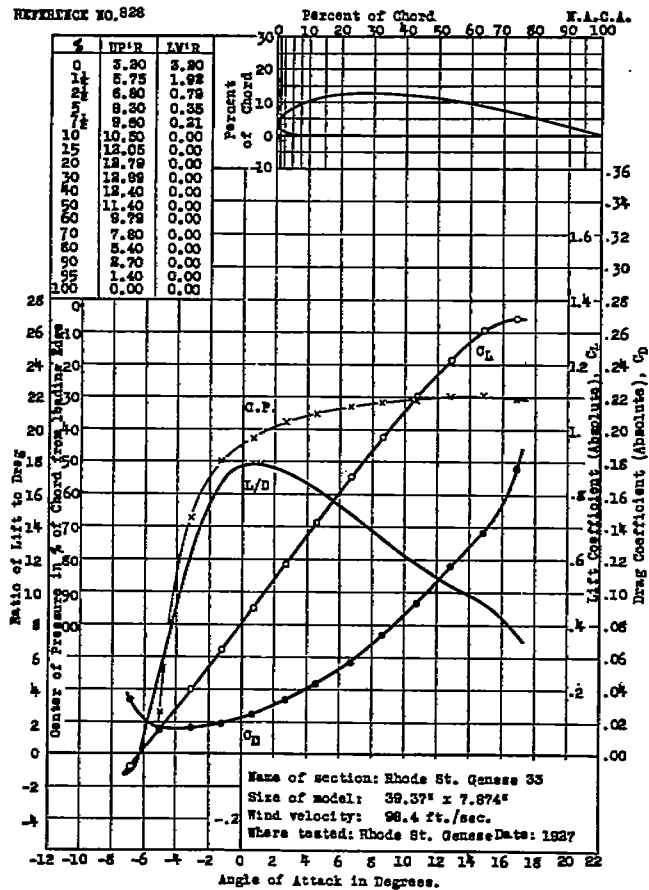
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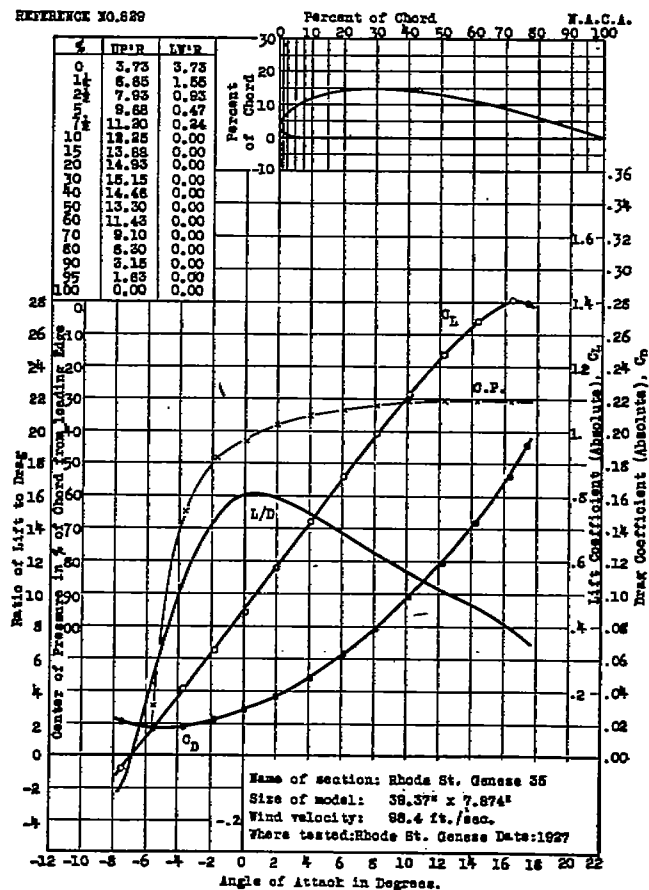
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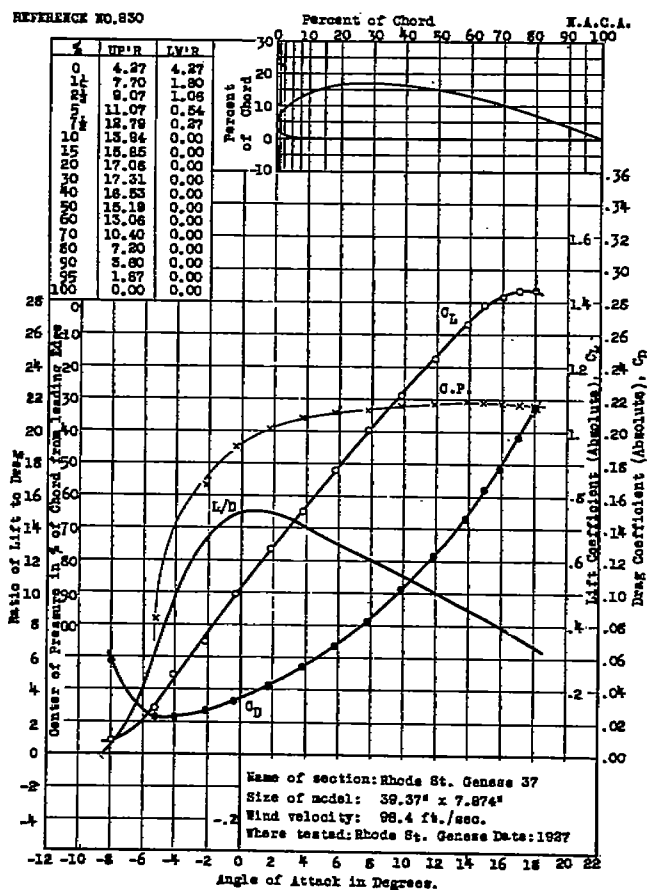
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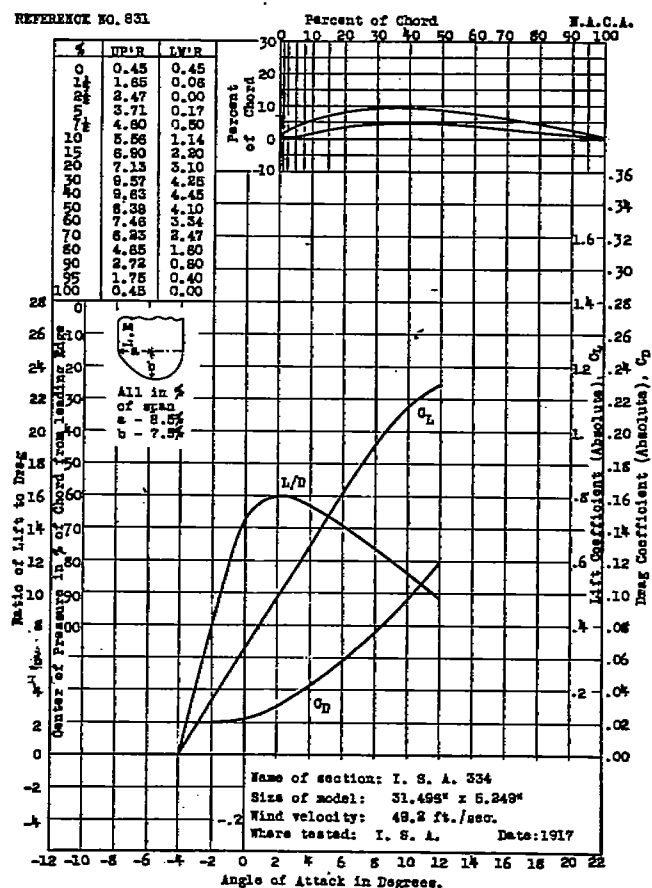
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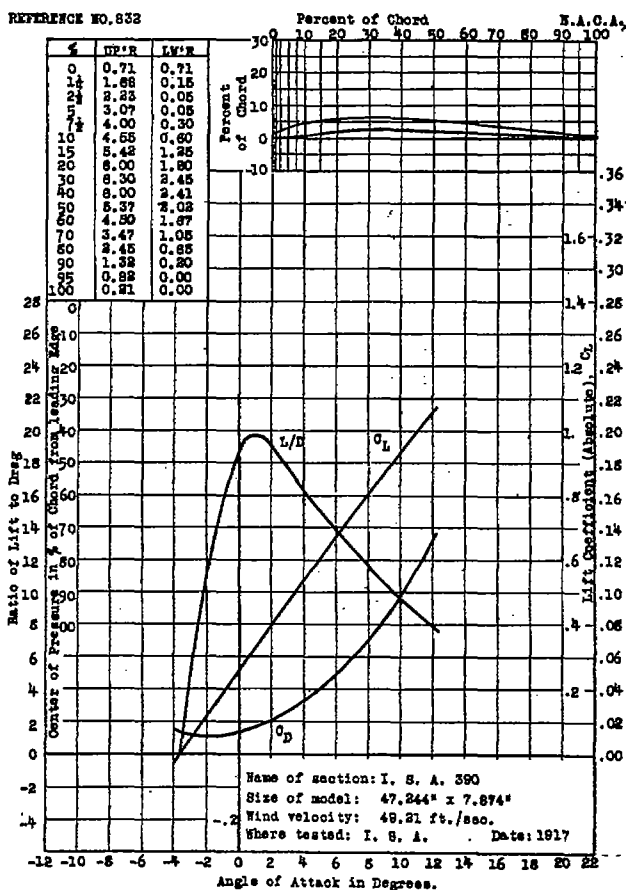
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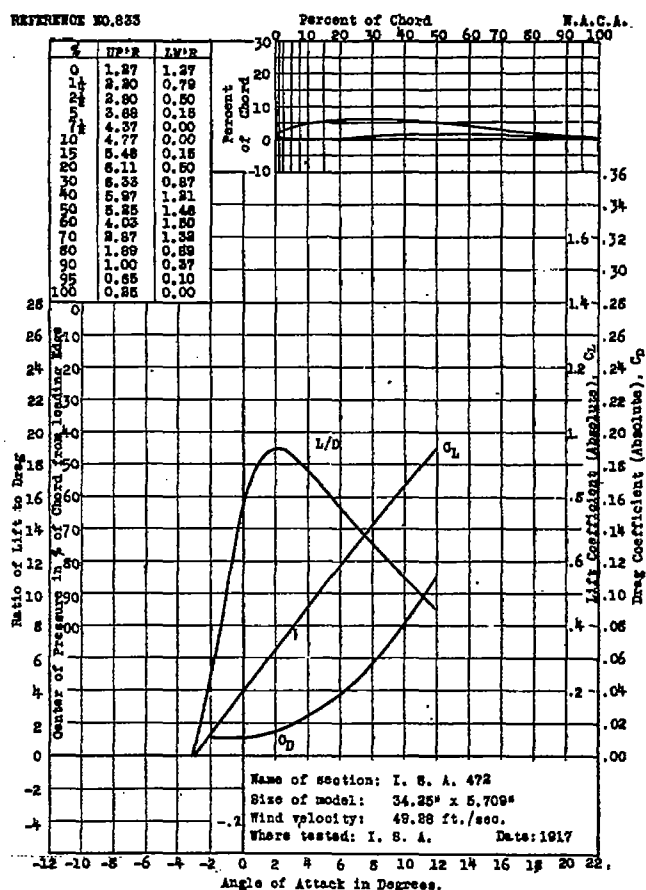
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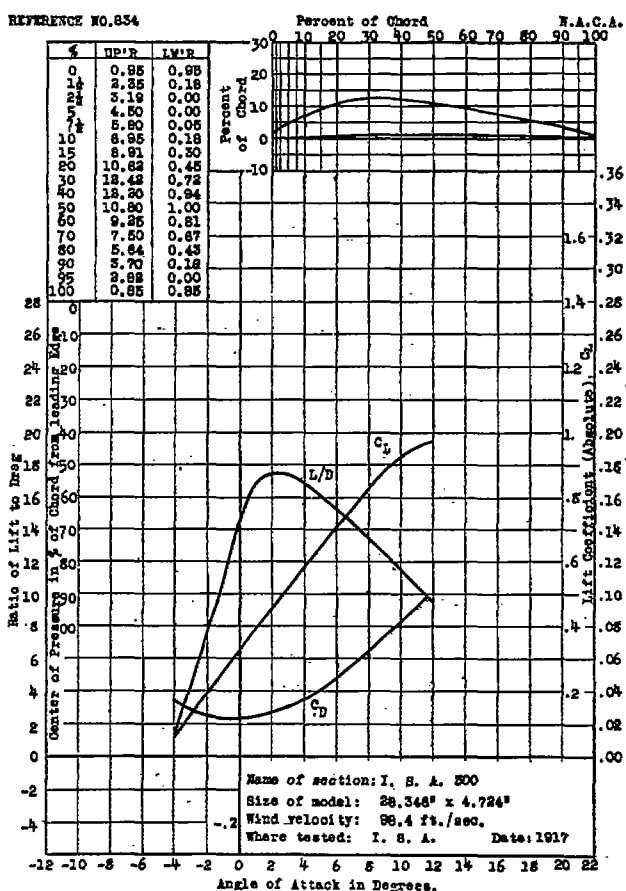
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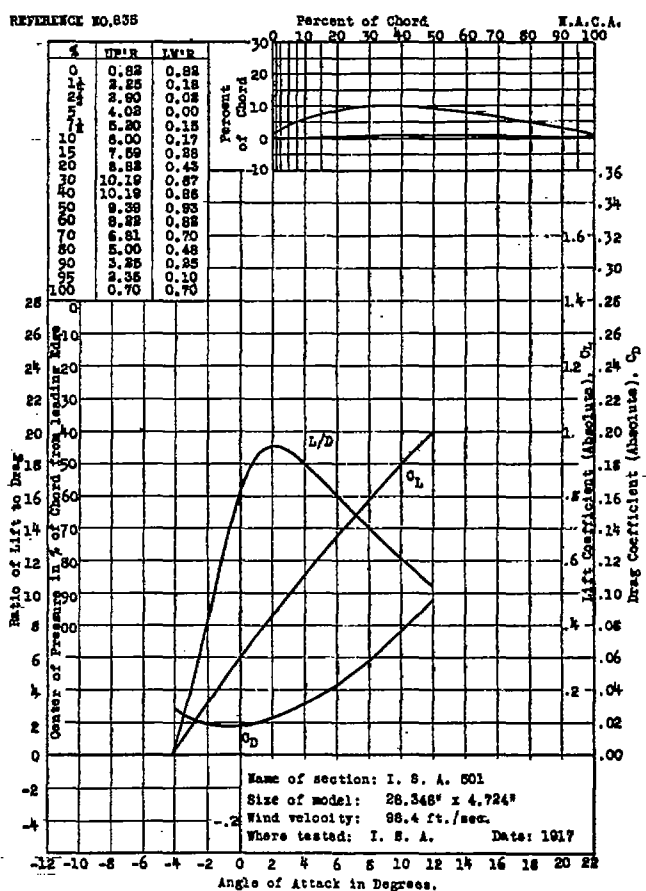
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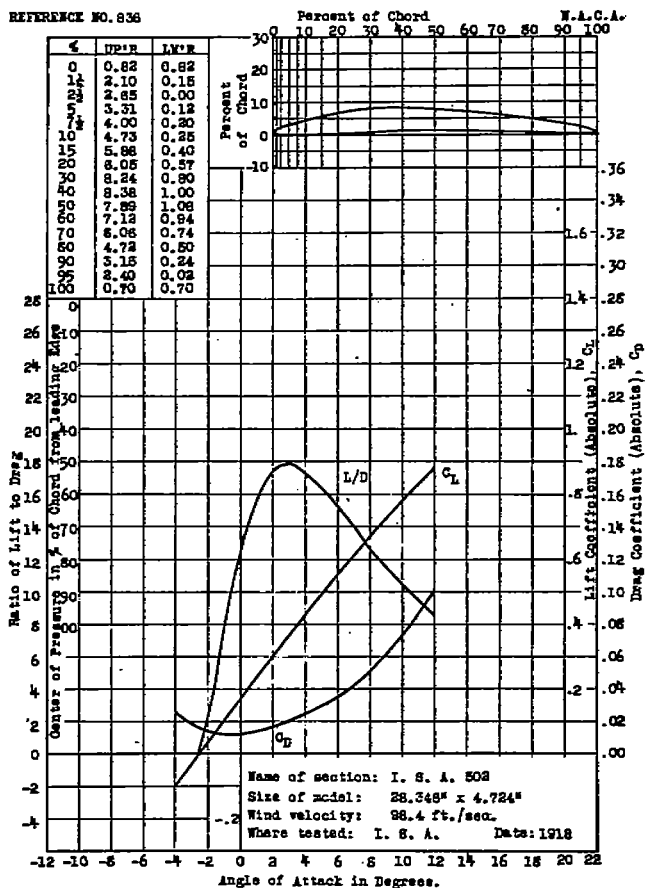
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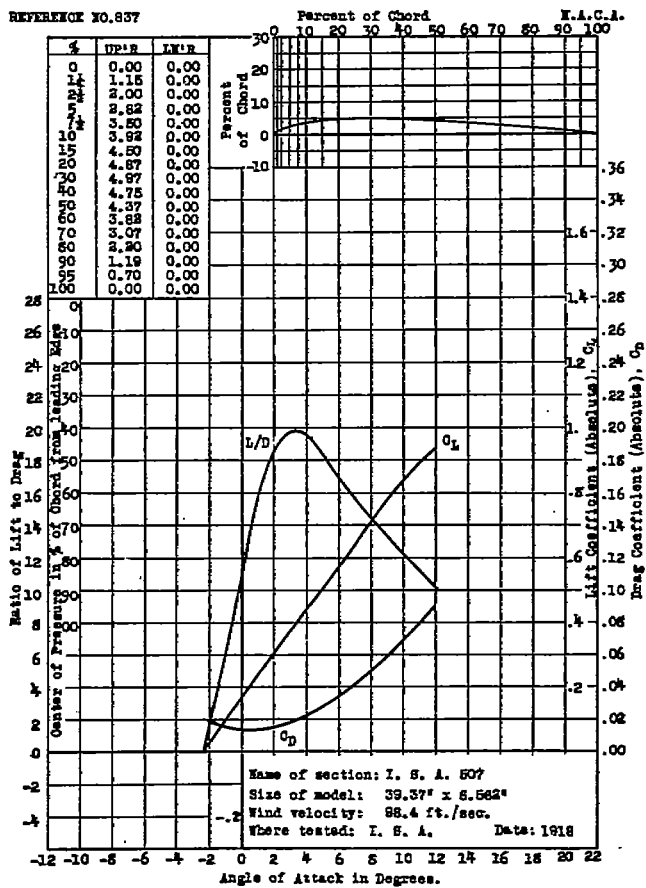
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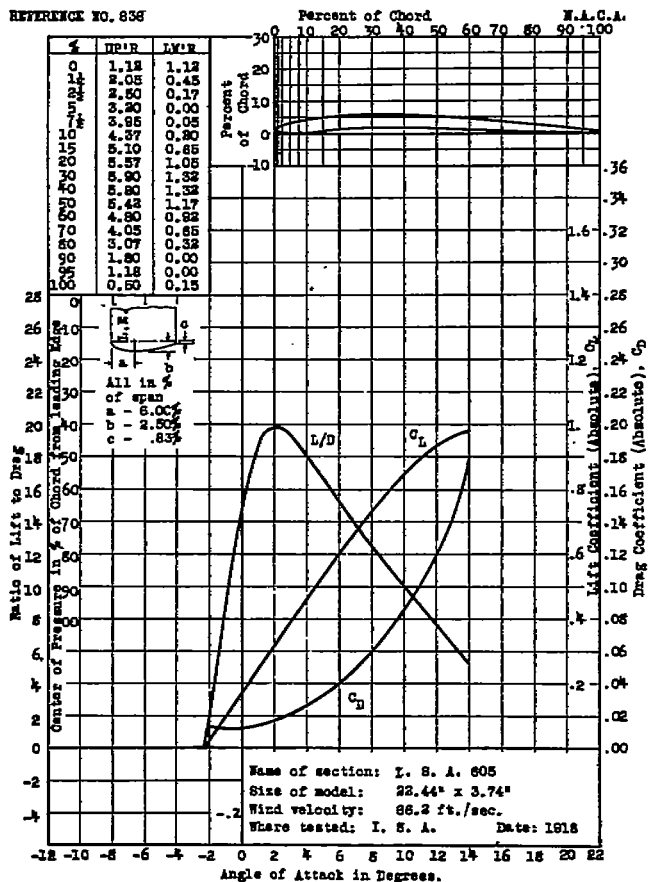
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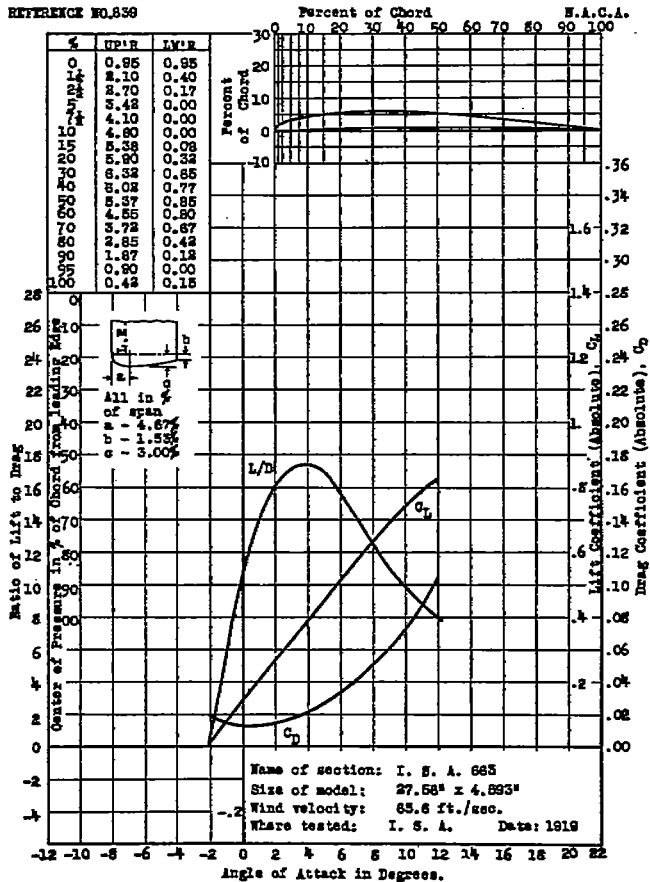
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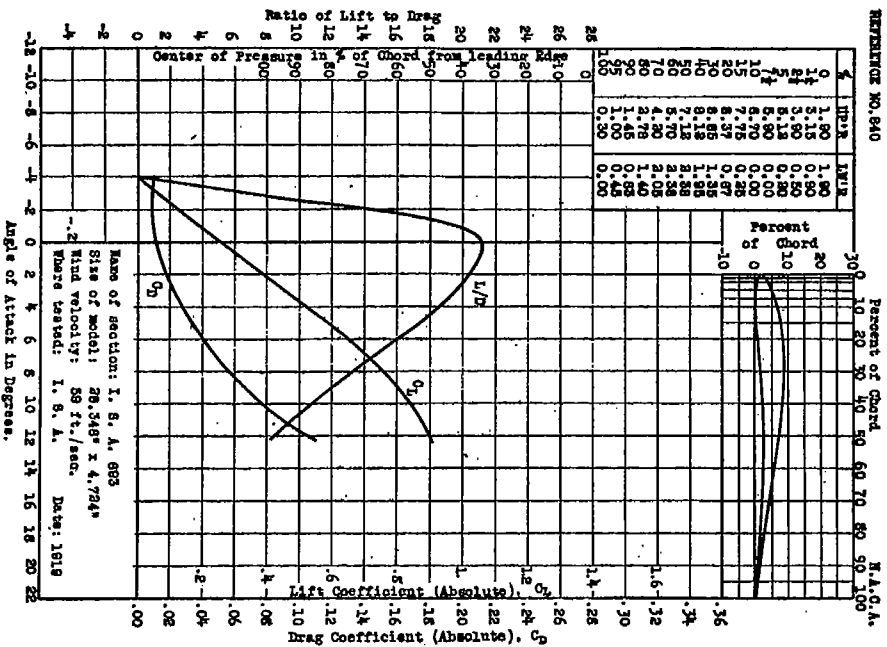
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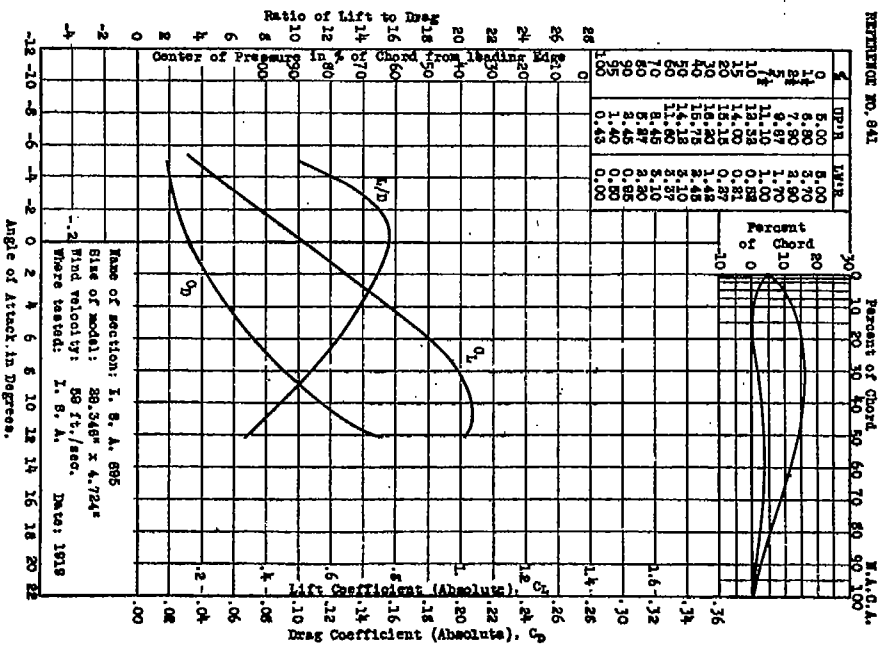
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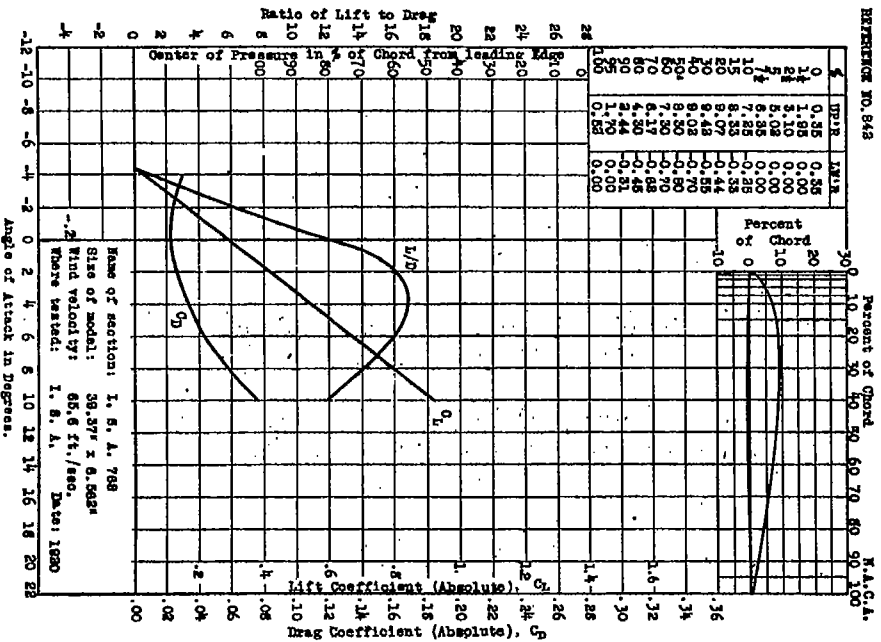
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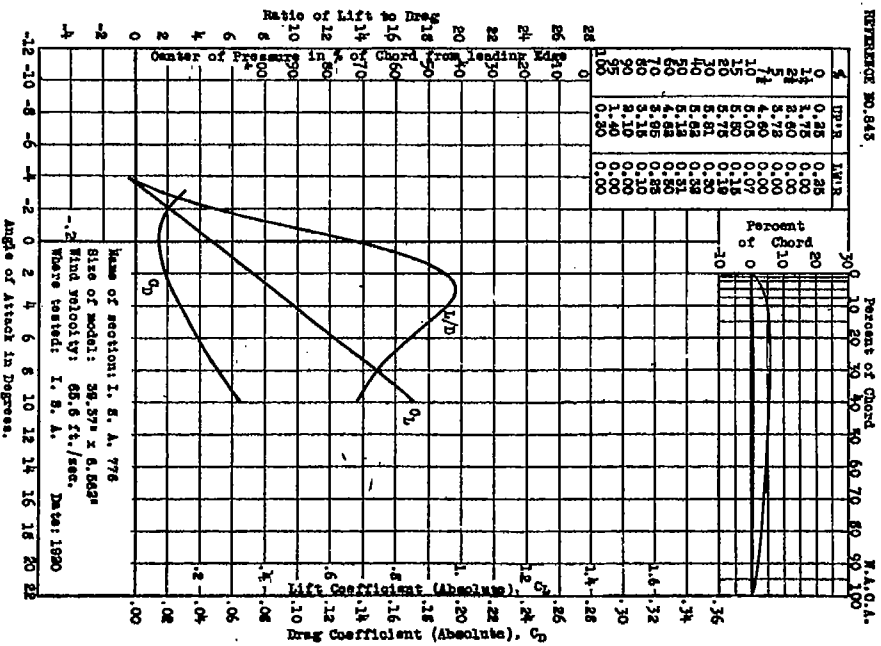
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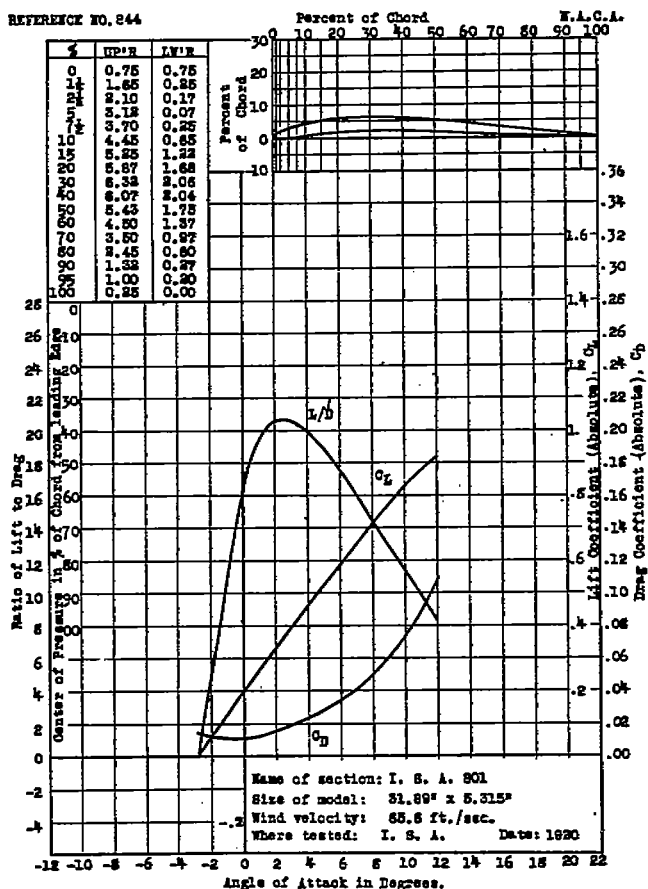
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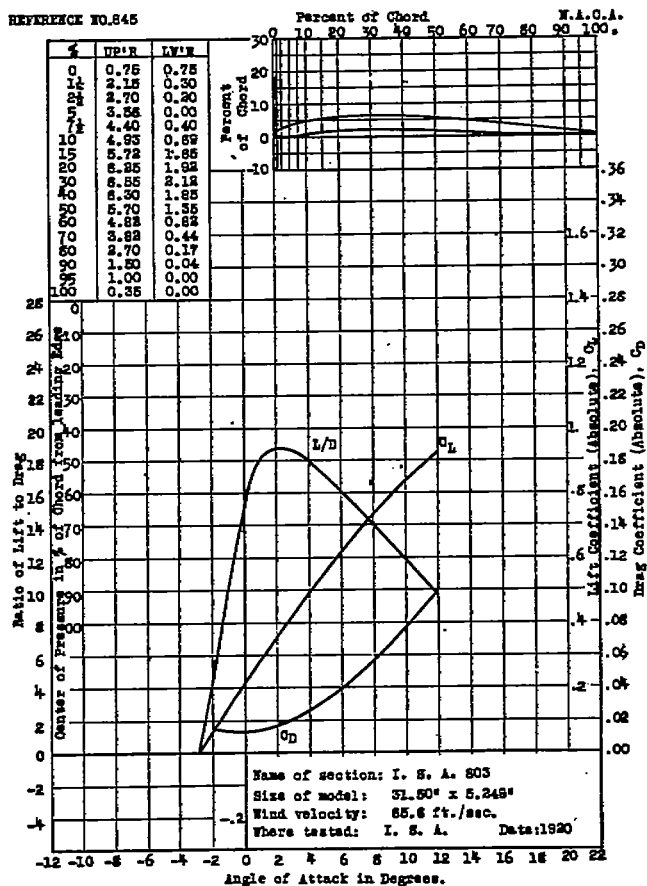
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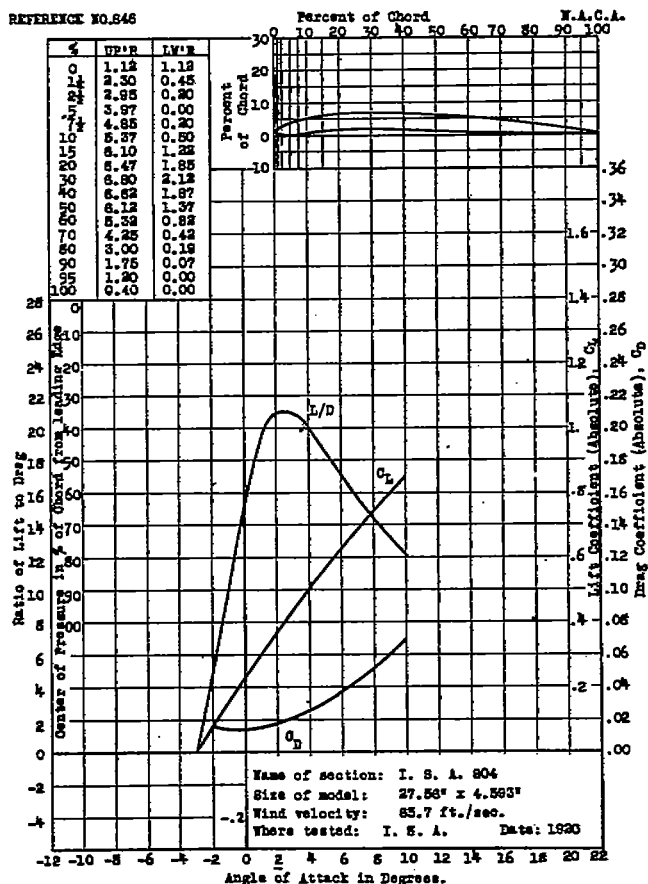
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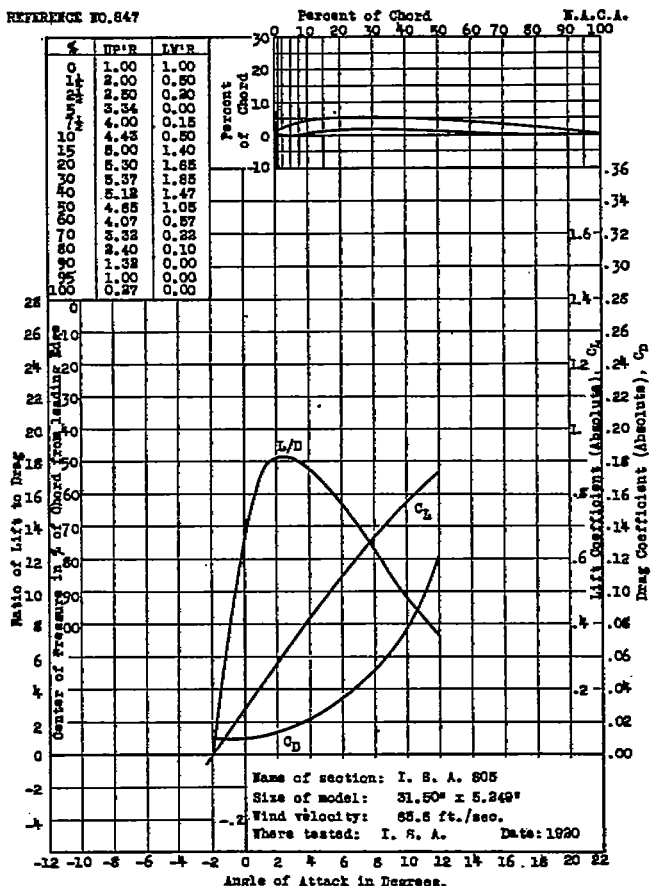
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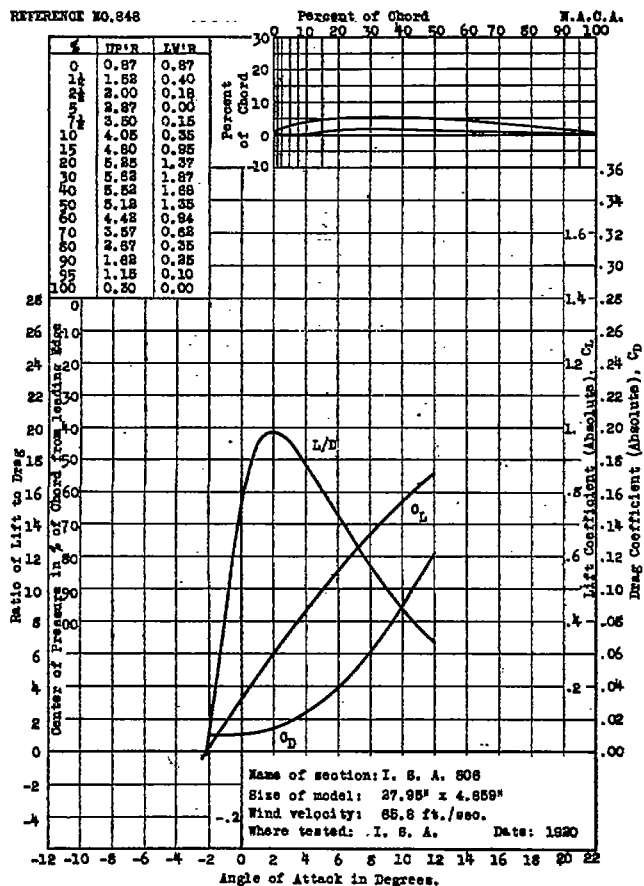
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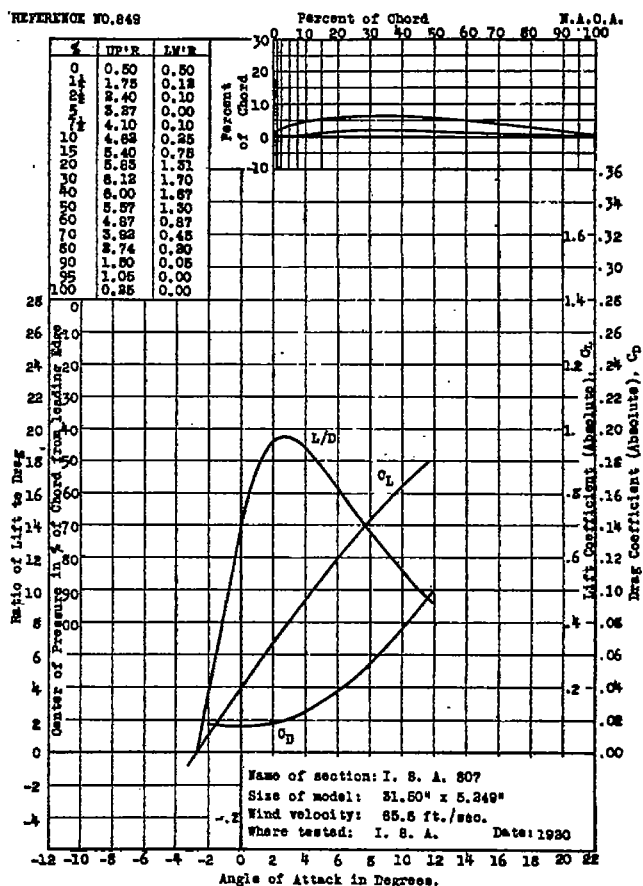
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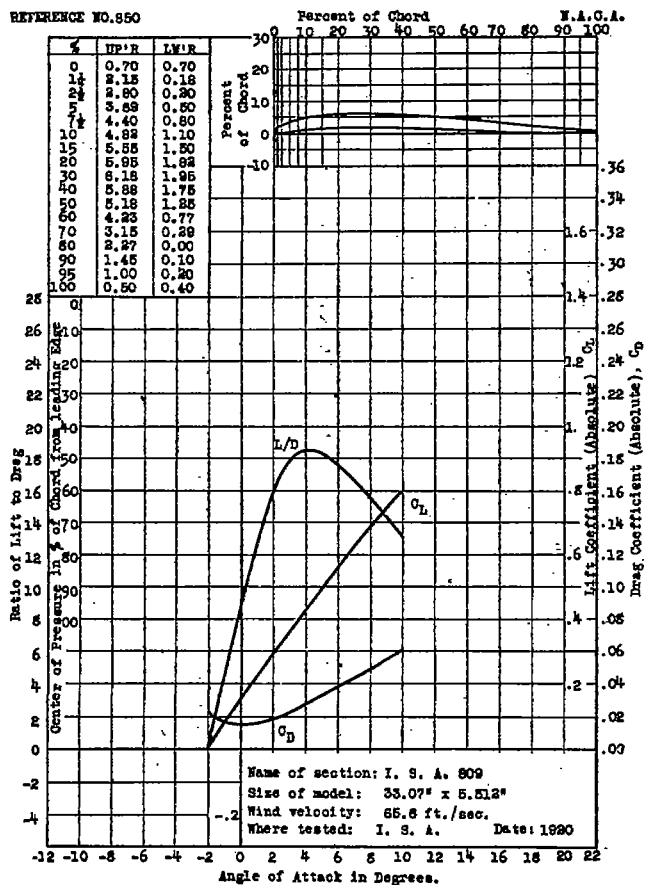
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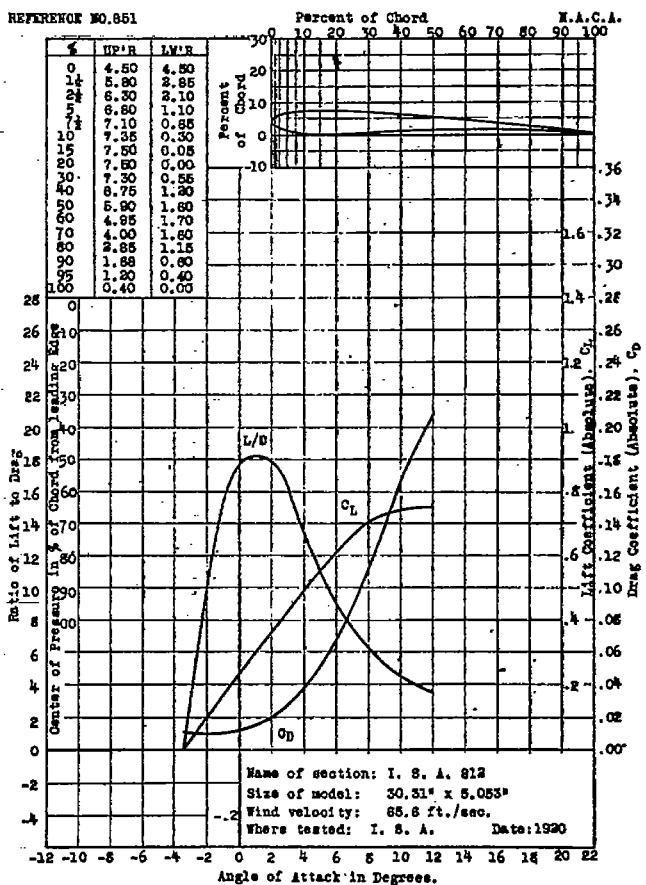
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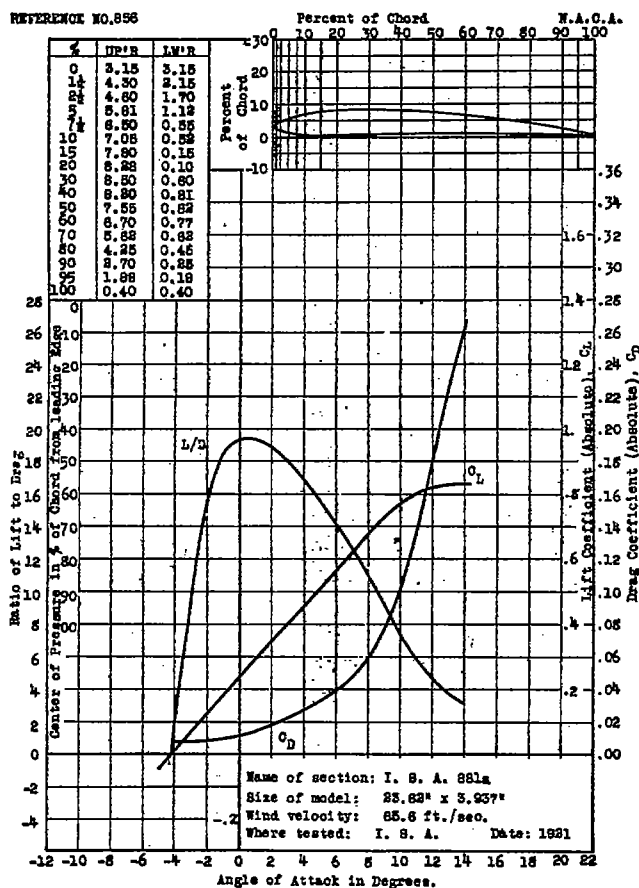
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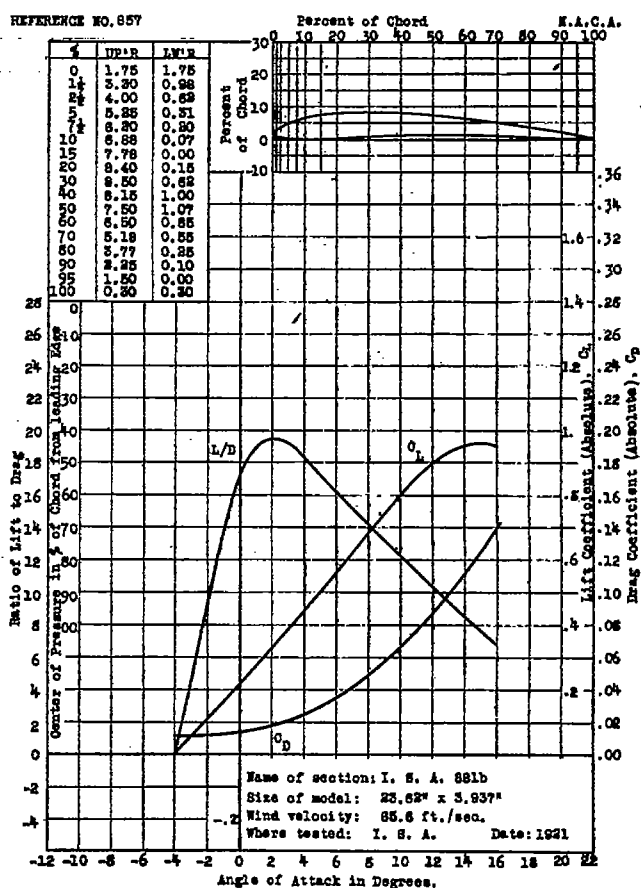
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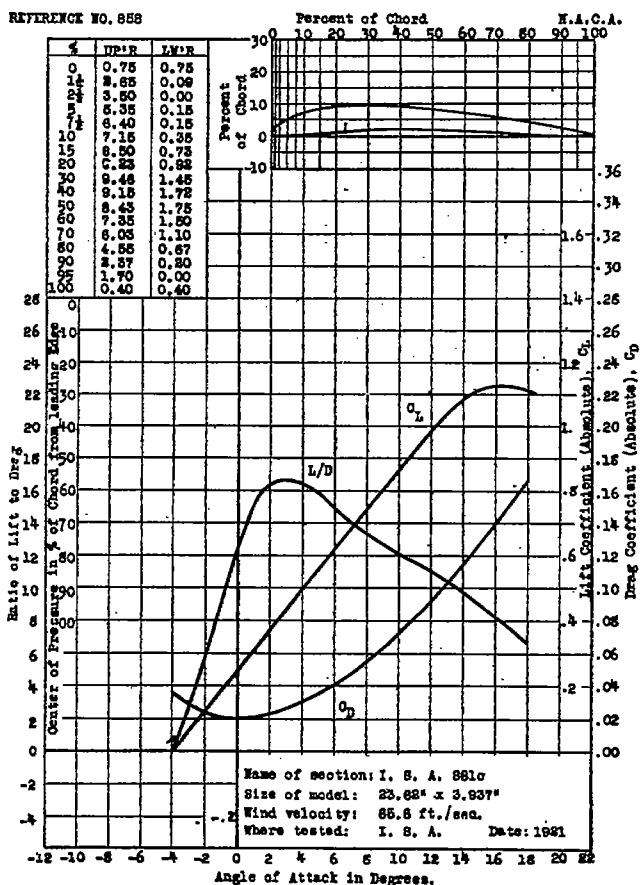
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REFERENCE NO. 858



REFERENCE NO. 859

